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Robert S. Binkerd is vice-chairman of the Committee of Public Relations of the Eastern Railroads. He received his Ph.B. from Yale University in 1904. From 1905 to 1908 he was secretary of the Municipal Voters' League of Buffalo, N. Y., then becoming connected for one year with the Citizens' Union, New York. For eight years Mr. Binkerd served with the City Club, New York. In 1917 he became assistant to the chairman of the Association of Railway executives which position he held until 1922.

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C. R. Brown is a senior at the Catholic University of America. He received the 1925 Charles T. Main Award for the paper which is presented in this issue. He is a student member of the A.S.M.E.

Lectures to Feature A.S.M.E. Annual Meeting, New York, November 30–December 4, 1925

At this Meeting there will be featured for the first time the Robert Henry Thurston Lecture, to be given by the Honorable Herbert Hoover, and the Henry Robinson Towne Lecture, which Dr. Zay Jeffries of Cleveland will deliver. These lectures have been established to bring more clearly before the members of the profession the results of scientific and economic investigation. They should prove the high spots in a Meeting already replete with interesting sessions.

MECHANICAL ENGINEERING

Volume 47 December, 1925 No. 12

The Transportation Industry and the Engineer

Development of Transportation and Industry in the United States Since the Civil War—Need of Trained Engineers in Transportation and Industry—Industry Dependant on the Successful and Profitable Conduct of Transportation

By S. P. BUSH,[1] COLUMBUS, OHIO

HAVING been invited as a representative of industry by the Pennsylvania Railroad Company to address your Society along somewhat general lines, it has given me much pleasure to accept, particularly on account of my long acquaintance with the company and my high regard for it, but also because of my deep interest in the engineering work of transportation and industry, with which I have been associated for many years, as well as what I conceive to be or should be a strongly mutual and related interest of all industry, transportation and otherwise, with the engineering profession.

I congratulate you on meeting here as the guests of the Pennsylvania Railroad, which has been for so many years keenly interested in scientific research and has contributed so much to the advancement of railway transportation, industry, and engineering.

The Pennsylvania Railroad for many years past has pursued consistently a progressive policy in transportation, in scientific research, and in the development of a corps of officers and men capable of carrying such a policy forward. Pursuing an enlightened policy it has become the largest transportation company on the American Continent as measured by goods and passengers transported, and from an engineering standpoint its achievements are notable throughout the world.

It is significant that just at this time the president of the Pennsylvania Railroad, Mr. Samuel Rea, an engineer-administrator, is retiring after a service of fifty-four years. To his vision, courage, and intelligence, and to all of those railway administrators, some of whom have been engineers, to those who have brought our railway system to its present state of high development, and to the engineer, the country owes much, and personally I feel that to my experience and association with the Pennsylvania Railroad, and to my engineering education, I am very much indebted.

It is not my purpose to enter into any technical discussion but rather to present to you some of the broader aspects of the relationship just mentioned, which, under changed and changing conditions growing out of the rapid and extensive development of the transportation industry, and in fact the entire economic condition of the country, with its consequent development of scientific requirements, have become so important.

The history of transportation and industrial development in America is so well known to you that it is unnecessary to review it, but suffice it to say that the entire economic development of the country has been largely dependent upon it, and with continuing growth of the country must necessarily become increasingly dependent upon it.

The complexity of economic conditions, not only in America but throughout the world, with the competitive struggle increasing in intensity, demands more and more the broader vision, more comprehensive understanding, and greater interest in the whole structure, to the end that we may continue to progress and maintain that balance and stability on which progress depends to a very large extent.

Originally, and before the days of the application of steam, ours was a maritime country and enjoyed world-wide preëminence as such for many years. The trained engineer played a very small part in the construction and operation of our sailing ships, in which was transported approximately 60 per cent of the world's commerce. With the introduction of the steam engine Great Britain assumed the leading position, and the maritime interests of this country were gradually reduced to very small proportions. Subsequently the country became mainly agricultural, but of recent years great changes have taken place.

Development of Transportation and Industry in the United States since the Civil War

The real development of transportation and industry in this country may be said to have commenced about the time of the Civil War, or about sixty years ago. This war and previous experience made it clear that it was essential for this country to be independent of the rest of the world in the production of all those things that are essential to the national defense. To this end a protective-tariff policy was inaugurated by Congress so that our natural resources and manufacturing might be stimulated to profitable development.

In 1900 the total wealth of the country was estimated at $88\frac{1}{2}$ billion dollars. In 1912 it was estimated at 320 billion dollars, which is sufficient to indicate how rapid and extensive our economic development has been.

At the present time the railways of the country, either directly or indirectly, consume 25 to 30 per cent of all its steel production, and about 25 per cent of all the bituminous coal it mines. They require a greater variety of commodities and service than any of our economic groups. They operate two and a half million freight-equipment cars and transport annually 2,300,000,000 tons of commodities and 950,000,000 passengers.

A division of the people into definite economic groups as a result largely of the transportation development, has brought to the front and to some extent visualized to them the dependence of each group upon the others, and particularly the fundamental importance of transportation as a basic industry.

Industry, by which is generally meant manufacturing, as the result of governmental policy and the development of transportation in this country has now become the greatest as measured by the value of production, and we are today the leading industrial nation of the world.

But while the engineer has done much toward the development of industry, particularly in recent years, I think it is within the truth to say that the larger part of our development has been accomplished by men who have not had the advantage of such institutional education as the country has afforded in recent years. Today the scientist and engineer are indispensable to most of our industrial and transportation development, which offer fertile fields of endeavor, both technical and administrative.

Need of Trained Engineers in Transportation and Industry

In this connection it will be of interest to you to know, if you do not already know, that on the suggestion of several industrialists, the National Industrial Conference Board, one of the most important research bodies in the United States, is now engaged, through a committee of industrialists and scientific educators, in

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Presented at the Altoona Regional Meeting of The American Society of Mechanical Engineers, Altoona, Pa., October 5–7, 1925.

ascertaining in what way engineering schools may assist in the better training of men for industry, and in what way industry may assist engineering schools. Many industrialists feel that graduates from technical schools have not received quite the right training or been given quite the right outlook. It has for a long time been a question as to how this might be done, and it is the purpose of the Conference Board to ascertain, if possible, the best course in this respect. It is significant to note that this industrial-research body is supported liberally and exclusively by industry, and has in its governing body and membership a number of engineers who deal almost entirely and in a broad way with the economic aspect of all the groups that go to make up the national life, to the end of aiding economic and social progress and stability. This is a matter in which I am sure your Society must have a very considerable interest.

In this connection I might mention that the Pennsylvania Railroad and some few of the larger industries in this country have for many years maintained a special apprenticeship course for graduate engineers, to the end of developing superior men, both technicians and administrators, and with excellent results; but since the World War there seems to have been considerable disinclination on the part of graduates to this rougher preliminary service, much, I believe, to their own disadvantage and to the best interest of industry and the engineering profession.

As further illustrating the wider field open to the engineer, I recall that shortly after the war, when the economic condition of industry in this country was chaotic and badly out of balance, the probability was that industry would have to face more severe competition and operate with greater economy than heretofore, Secretary of Commerce Hoover, himself an engineer, desiring to ascertain the real facts in the case and what might be done to put industry on a better basis, appointed a commission of engineers to investigate and report; and the results of this investigation some of you are probably familiar with. It was significant, although not extraordinary, that he should have selected engineers to undertake this task, for the engineer's work is very largely that of honestly and truthfully finding, recording, and facing facts. It was probably not within the scope of this commission's work to relate the conditions they found in the industrial field with those of others, but I think it must be clear that this relation not only exists but is at the bottom of our economic fabric, and it would seem that the engineering profession as a group, in its own interest, as well as that of the general welfare, might interest itself more widely in the national aspect of this relationship. Reduced to the smallest possible terms, the substance of this commission's report was the elimination of waste through specialization, standardization, and stabilization.

President Rea of the Pennsylvania Railroad in a recent statement has said that he believes the opportunities for young men to succeed in railroading are better today than ever; that a higher class of mental and physical equipment for leadership is required than fifty years ago; that while the development of railroads might not be in opening up new territory, the necessity for new and better methods is more urgent than ever. Revenues must be increased, expenses reduced, waste eliminated. No branch of the service is freed from the necessity of invention and progress of that character. I might add that the same may be said of industry.

These statements and facts presented to you I believe to be of interest to the engineering profession as a group, holding as I do that men with the proper training and outlook are much needed in industry, and because I am convinced that technical and scientific education furnish the best foundation on which to build for both the technician and administrator in both transportation and industry.

I might here mention that in a few instances and in the company with which I am associated, the organization in the main, including a large part of the sales department, is made up of educated engineers.

NEED FOR BROADER VISION BY VARIOUS GROUPS

If I were to suggest to any group one thing more needed than anything else at the present time, and which I believe will be required at no distant day, it would be a broader vision and a far wider consideration of all the groups essential to development in the future commensurate with that of the past. All groups heretofore have been too prone to concentrate their interest on their own particular problems, and have failed to realize the economic dependence of one upon another.

This is directed particularly to the administrator in general, but I would point out to the engineer as well that the field of his endeavor for his own material welfare must necessarily be restricted and progress retarded unless each group exerts some influence in effecting the economic welfare of all the other groups by discouraging those proposals and efforts—sometimes enacted into law—which put one group or another at a serious disadvantage, or give one group an undue advantage over others.

Mr. Rea, in the statement to which I have referred, points out that the greatest stride in the railway-transportation industry in the matter of sound finance and service took place between the years 1899 and 1907, when railway management was far less restricted than at present. Since 1907 railway development has been seriously retarded until recently, through the application of much injudicious governmental policy. He states that in all business questions affecting the railroads he feels sure that the best satisfaction would be given to both railroad owners and the public if the process of interfering with the responsibility and judgment of managements should be halted and public regulation used as an impartial medium for adjusting or avoiding difficulties between railroad users, railroad owners, and the managers, with a view of providing service without discrimination and at the lowest compensatory rates.

INDUSTRY DEPENDENT ON THE SUCCESSFUL AND PROFITABLE CONDUCT OF TRANSPORTATION

If transportation cannot be conducted successfully and profitably, the engineer and industry will have a very meager field of endeavor; and it would seem that the maintenance of the transportation industry on a sound and profitable basis is a matter that should concern us even more than some of the other technical problems to which we devote so much of our time and interest.

As illustrating the matter, I would call your attention to the fact that in the years from 1912 to 1924, inclusive, the Class 1 railroads of this country, representing a total of 235,000 miles or approximately 95 per cent of all the railroads in the United States, were not able to earn as a whole, except in one year, the $5^3/_4$ per cent on appraised values established by law as a fair return. Covering a period of three years after Government operation, which was relinquished at the end of 1919, the average earnings were but 2.36 per cent. At the present time conditions are much improved as the result of the most highly efficient management and operation that the railways have ever known, and because of a substantial reduction in the cost of nearly everything that the railroads require for their use. Transportation, as well as agriculture, is seriously handicapped, and the purchasing value of its services or product as the result of continuing high wages of labor with high consequent cost—effected to a very considerable extent by governmental policy during the war—has been considerably less than before the war.

The effect of this condition is to put our economic structure out of balance, to the detriment of the entire country. Were it not for the enormous resources of this country our position might easily be serious.

Is it out of place to suggest that engineering groups, through their various organizations, might make themselves felt in influencing a policy that will prevent the depletion of a great basic group to the disadvantage of the whole? We in industry have been compelled in our own interest to exert ourselves actively in this and similar matters. Deplete the earning and purchasing power of transportation or agriculture, and industry and all other groups suffer.

Mr. Rea further states:

> The available facts show that the Pennsylvania Railroad has kept pace with the growth of the country and successfully met periods of expansion and depression; it has surmounted the crest of long-continued depressing legislation and regulation and the far-reaching consequences of the World War; it has survived the continuous struggle to prevent confiscation of the railroad investment; it has helped in bringing about a better-informed public and a closer understanding of the necessity for strong railroads with ample net returns; it has always been conservatively managed, has experience and traditions of inestimable value, and is considerably undercapitalized and is one of the effective instruments of national prosperity.

Is not this of material interest to the engineering profession as a group? This is not a matter of politics, it is a matter of sound economics.

PROBLEMS IN TRANSPORTATION AND INDUSTRY AWAITING SOLUTION

As has already been said, one of the problems to be met in the future is the elimination of waste, or of effecting more economic operation and stabilization. Much has been accomplished in this direction of late, but there is vastly more yet to be done, and the need extends into every avenue and detail of our economic structure.

Transportation and industry operating under the necessity of developing not only a living wage but some profit through which alone progress and development may continue, under our highly competitive conditions, needs men to point the way and to develop the method, and as I have already pointed out, the engineer must necessarily play a highly important part. The Secretary of Commerce, Mr. Hoover, is conspicuous in this. Without going into too much detail may I suggest a few possible avenues:

Has steam-railway motive power seen its final development as to economy of performance?

Has the deadweight of transport vehicles and train resistance been reduced to an irreducible minimum? It appears that we are yet far from it.

Has the life of rails, ties, wheels and axles, and many other things been brought to a maximum impossible to exceed, and their cost consequently reduced to a minimum? It would seem not.

Here are a few problems for the technician of both transportation and industry:

Has the best labor result and cost yet been developed in industry and transportation, or has the greatest incentive to labor yet been found and applied in a general way, or has the best relation between labor and management been arrived at generally?

Cannot the enormous wastes arising from violent but in a way normal fluctuations in production and employment of labor and capital be seriously grappled with?

STEADY AND REMUNERATIVE EMPLOYMENT ESSENTIAL TO A SOUND NATIONAL LIFE

If there is one thing more than anything else essential to a sound national life, it is that the people shall have steady and fairly remunerative employment.

Upon investigation just before the war—and similar conditions have prevailed largely since—it was found that the steel industry as a whole, with its enormous investment and large force of employees, was occupied but 70 per cent of the time; that the bituminous-coal-mining industry was operating at but 50 per cent of its capacity; that the car- and locomotive-building industry was operating on an average but 65 to 70 per cent of the time. In the car-building industry and the industry in which I am engaged, business has fluctuated frequently from an operation of 10 per cent to that of full capacity.

This represents an enormous waste and affects seriously the employment and morale of the worker. Employment and progress in industry and transportation without profits are impossible, and profits are impossible without the continuous elimination of waste.

These are problems for the administrator and technician which, in the light of present-day conditions of national and international character, make many other things appear insignificant.

As I have said, the man with scientific training and with practical experience is, in the opinion of many, best equipped to meet these problems.

Mr. Hoover's committee of engineers summarized the result of their investigation as to what was needed in three words: "Specialization," "Standardization," and "Stabilization."

I think it must be clear that if we are to have sound progress, balance and stability are essential factors in all of our life and development; and as a principle no one ought to understand this better than the engineer. Here are essential elements not only to higher economic development but to social peace and progress.

What I wish to suggest from this is that we in industry have come to a partial realization at least of the fact that not only must we work out the problems of industry as such, but we must also see the problems in other groups, such as transportation, agriculture, and education, and assist them in their solution.

Now, the substance of all that I have endeavored to present to you is that industry in order to meet the problems of the future is going to need, generally speaking, more men of broader vision than heretofore—in fact, superior in all respects—and that scientific education, revised somewhat to meet the more complex conditions in order to assist in producing such, would be highly desirable; and if the organized engineering groups could lend their influence in support of sound economics, it would be very helpful.

Technical Training in Industry

By JOHN P. KOTTCAMP,[1] MANVILLE, N. J.

DURING the past few years there has developed an ever-increasing interest in the subject of technical training. The A.S.M.E. in recognition of this interest appointed a committee on Education and Training for the Industries. Due to the activity of this committee a part of the Annual Meeting program has been set aside for a discussion of this important subject. The leaders in industry and in education are getting together to study the methods by which men are to be trained for the important industrial positions. Both sides are cognizant of the fact that at the present time the demand for technically trained men is greater than the supply. As the older men in industry are gradually passing on, it becomes imperative that men be developed as understudies, so that when the time comes they may step into positions of greater responsibility.

Under the old system of management the average executive rather discouraged an excessive amount of ambition and initiative in the men down the line. The typical foreman felt that his job was to keep his end of the plant in operation. The thought of actually studying his men with a view to developing them so as to make them of increasing value to the company was foreign to him. A new day has dawned. Industry now recognizes the fact that, to be successful, a foreman must be more than a mere "gang boss." He must learn to know his men—find out the possibilities in his men—teach them discipline and at the same time hold their respect and confidence. Further, he must be constantly studying the problem of how to increase not only the output but also the quality of the output, and in addition he must face the problem of reducing production costs. The result of this new condition is that the average foreman who has been denied any technical training suddenly finds himself seriously handicapped.

Again, the foreman of today who would be successful must develop those qualities of leadership which will spur on his men to give of their best. Some will say that many of our successful executives today are those who have come up through the ranks and who have had little if any technical training. Many were denied even a high-school education. We recognize this fact, but we also recognize the fact that, given two men of equal personal characteristics, the one trained and the other non-trained, the trained one will come out on top of the pile.

Until comparatively recently the main source of supply of technically trained men was the typical four-year engineering college. The graduates of the various colleges have been a wonderful asset to industry. Any thing that can be done to increase and improve the output of our colleges is highly desirable and commendable.

The output of any factory is limited in most cases to the supply

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of the proper grade of raw material. There is not much use putting in additional equipment unless a new supply of raw material can be found. This is somewhat the condition of our engineering colleges. Their source of raw material is limited to high-school graduates who are so situated as to be able to afford the time and money for four years in college. Many of these young men enter an engineering college and after a few months, or a year, find themselves to be a "misfit." The result is that the percentage of those entering our four-year engineering colleges and successfully completing their course is not as high as might be desired. It is also true that much excellent work is being done to remedy this condition. The requirements for admission are being made more severe. Not only must the applicant present proper academic credentials but he must also satisfy the college authorities that he has a reasonable chance of making good in industry upon the completion of his course.

Over and above the supply of raw material of college grade there is another supply which for a long time has not been touched. This supply is made up of several classes. First, we have a large number of young men who have been denied a high-school education, due to home conditions over which they have had no control. Second, there is the young man who has successfully completed his high-school course but whose financial condition makes college an impossibility. In all probability there are others dependent upon him, so that even if he were loaned the money for college, he would be unable to go. Third, there is the young man who has had a year or two of high school. Then suddenly he was forced to leave school and go to work. After a few years he finds others passing him by in the line of promotion and he realizes that his greatest handicap is a lack of training.

What about these three types? Are they to be denied a place in industry because of their lack of an education? Is there any way of their obtaining this training? The thought comes to mind that they can attend evening school. The process, however, is necessarily slow, owing to the few hours that can be put in per week.

There is also a fourth type consisting of the young man who was denied a complete high-school education. At the age of 14 or 16 he went to work. He was thrifty and at the age of 22 or 23 finds that he has saved enough money to devote some time to study. Aside from the fact that he is lacking in the requirements for admission to college, he finds that he cannot afford to give up four years to this work. Here again we ask for the solution of this man's problem.

This brings me to one method of meeting these problems and at the same time increasing the supply of technically trained men for industry. One solution of the problem is the introduction of intensive courses of study limited to two years in length, and so arranged as to make it possible for the men coming under the four classes I have outlined to be admitted and successfully trained. The first reaction to this proposition is that it cannot be done. The fact that today there are thousands of men in industry who have been trained in this manner is sufficient proof that the plan does work.

Since the course is limited to two years, it must of necessity be made intensive in character and limited to those things which will cover the fundamental principles essential to industrial success. Again, if the course is to be intensive in character, it becomes all the more necessary that the raw material selected shall possess those qualities which will enable it to stick and make good.

To succeed in such a course the student must be mature, serious-minded, qualified for the line of work he has chosen, and have a definite objective in mind—namely, to make good not only in his course but also in industry upon graduation.

The content of each course must be carefully selected—all frills and camouflage must be eliminated. Strong emphasis must be placed on the necessity of mastering fundamental principles. If the subject is mathematics, it is necessary that the student be made to understand that this subject is the foundation on which all engineering rests.

In addition to the necessary technical subjects it is vital that each course contain a certain amount of English, and that the work in English be limited to that of a business character. In our two-year course it is more essential that the student be able to write a good business letter than to compose a beautiful poem. A knowledge of the essentials of business administration must be acquired by the student in this intensive course.

Finally the course must be rich in work which will bring to the attention of the student the need of character development. Many students successfully complete a technical course but fail in industry. The answer is simple: While students they failed to recognize the need for self-discipline, and loyalty to their work. They failed to assume responsibility—instead of developing the power of thinking, they left others do their thinking for them.

Prior to graduation from this intensive course the student must be made to realize that he is laying a foundation only—that the structure he has in his mind's eye will take years of hard work to erect. To make good he must be willing to enter industry at the bottom of the ladder, and then climb only as he successfully attains each rung. Any attempt to skip several rungs will result in bruised joints.

Too often we fail to emphasize to the student the important part that personality plays in industrial success. Other things being equal, the man of strong character and pleasing personality is bound to succeed over the man whose moral standards are low and whose aims are purely selfish.

As far as possible all the work given in shops, laboratories, and drawing rooms should be of a commercial character rather than a series of set exercises. The student will take far more interest in his work if he knows that the thing he is making is to be put to some practical use.

Combined with the above characteristics, the course must contain definite prescribed physical training. No training can be complete without this element. The development of a sound mind that will function under the stress and strain of industry is impossible without the development of a sound body.

It is my firm belief that the strongest course is the one developed to meet the actual needs of industry. The school does not know fully all these needs. Hence it is incumbent upon industry to study this problem of technical training—to write its specifications of the product it desires—and then to assist the school in every way possible to see that the specifications are followed in all details.

The A.S.M.E. committees on education have a great work before them. Industry is looking for help and it is incumbent upon these committees to study all methods whereby the supply of technically trained men can be increased. The introduction of schools giving intensive two-year courses in the fundamentals of engineering will help in a large measure to solve the problem of finding an adequate supply of qualified technically trained men.

The New Employee

IT IS a commonplace among executives who are responsible for the management of our large corporations that some substitute must be found in industry for the close personal relationships of the past. Large-scale production, bringing in its wake the removal of the man on the job further and further from the man or men in charge of production, has dehumanized the manufacturing process to such a marked degree that executives may well be alarmed. One of the most costly results is the present high labor turnover which is a tremendous charge against industry today. When it becomes necessary, as is the case in many plants, to employ three hundred men during the course of the year in order to maintain a working force of one hundred, the situation becomes serious, and need of remedy imperative. The cost of training three hundred men to new jobs is only one of the many charges which result from high labor turnover.

The present high turnover during the first few months of employment can be very materially cut down, as it has been in many cases where the problem has been turned over to the human relations expert, with the result that the new worker is properly initiated into his work. If you can convince a man at the start of a new job that you are watching him and have something in mind for him when he has prepared himself for it; if you help him right at the start to make friends in your institution; if you build up his knowledge about, and interest for the institution, so that he feels a part of it, and that it is a part of him—the chances of his becoming dissatisfied and leaving in the first few months of his employment are remote indeed. M. A. Myers in *Industrial Management*, November, 1925.

The Growth of a Great Transportation System

The Story of the Pennsylvania Railroad—Some of the Important Steps That Have Been Taken by Its Management and the Policies It Has Followed—The Future of the Railroads

By A. J. COUNTY,[1] PHILADELPHIA, PA.

THIS is a gathering of engineers, and I take it that instead of dwelling on theories as to The Growth of a Great Transportation System, the subject assigned to me, I should take one of the country's large systems as an illustration. After 35 years of service I should be able to speak of some features of the Pennsylvania Railroad. Its growth is typical of that of other large transportation systems and I will review briefly some of the important steps taken by its management and the policies it followed. The result is that it has grown gradually from a railroad 244 miles long, built within the confines of the state of Pennsylvania 71 years ago, to a system extending well toward half-way across the American continent.

The Charter

With sound engineering and available capital at reasonable cost, most of the world's troubles can be relieved and the standards of living greatly advanced. After all, it is the welfare of the citizens which underlies construction, output, and capital expenditure. If railroads do not give satisfactory service to the citizen, or the citizens will not or cannot avail themselves of it, the railroad investment is on the way to the graveyard. I am constantly told that we must give service to the public. If any group will show us how to make and keep the railroad investment profitable without putting public service first of all, a large sum of easy money awaits them. To trace growth we must begin with the charter. The facts surrounding the granting of the charter to the Pennsylvania Railroad and the raising of the preliminary capital for its construction are of historical interest. They will bear repeating.

Philadelphia is a great city, but don't forget that until the completion of the Erie Canal in 1825, it had been the great commercial and financial center of the United States, as well as its largest city in population. The opening of that canal, and the subsequent failure of a number of Pennsylvania financial and industrial institutions in the panic of 1837, caused it to unwillingly surrender its prestige to New York City as the commercial metropolis of the country. The city of Philadelphia and the state of Pennsylvania, therefore, had to stand aside and see the profitable trade of the West go through to New York via the Erie Canal, or through to Baltimore via the Baltimore & Ohio Railroad route. The merchants of Philadelphia and Pittsburgh thought they could meet this competition through the building of a canal and rail system of transportation across the state of Pennsylvania. Private capital was not available or willing to undertake the vast enterprise, so in 1826 the state courageously embarked on the construction and operation of its own line of public works across the state of Pennsylvania, consisting chiefly of a railroad from Philadelphia to Columbia, 81 miles; a canal from Columbia, following the Juniata Valley, to Hollidaysburg at the foot of the eastern slope of the Allegheny Mountains, 172 miles; a portage road with inclined planes on each side of these mountains to Johnstown, 37 miles; and a canal from the latter point, via the Kiskiminetas and Allegheny Rivers, to Pittsburgh, 104 miles; a total of 394 miles. I am old enough to have known some of the engineers employed on these works in their young days. These public works were completed in 1834. It was freely admitted after a few years of operation that they were a complete failure as a medium for competing for western traffic with the neighboring routes on the north and south in other states, and so for the next ten years there was continual agitation for their sale. But, nevertheless, the state works were the outposts for our advance in transportation methods and low rates, and it required considerable courage and capital to undertake them. They represented the central Pennsylvania through route, but they were inadequate to carry the traffic of the state.

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Address delivered at the Altoona Regional Meeting of The American Society of Mechanical Engineers, Altoona, Pa., October 5–7, 1925.

Meanwhile, as the result of an aroused public opinion in Philadelphia and Pittsburgh, a movement began for the construction of an all-rail route from Harrisburg to Pittsburgh under the name of The Pennsylvania Railroad Company, or the Pennsylvania Central Railroad as it was popularly called. The year 1846 found the promoters of this project before the legislature at Harrisburg with an application for a charter, but they were opposed by other interests who sought a renewal of the lapsed privilege to extend the Baltimore & Ohio Railroad from Cumberland, Md. to Pittsburgh, Pa. The Pennsylvania Railroad project was successful, but only after a strong appeal had been made to the civic pride and commercial interests of Philadelphia, and after a house-to-house canvass for even single-share subscriptions, aided by large subscriptions from the city council of Philadelphia and the commissioners of Allegheny County. The project was regarded as a necessity to commerce but a speculation to the bankers and investors. From the outset, interest on the share installments had to be paid, first at 5 per cent, which had to be increased to 6 per cent to attract the funds.

As the Pennsylvania Railroad was looked upon as a competitor of the state works, there was a provision inserted in its charter requiring the company to pay a tax on each ton of freight carried over the road between March and December of each year. The winter months were omitted because, notwithstanding all their advocates say, canals did freeze in this climate and they were exceedingly costly to operate, and in winter the railroad was a necessity and not a competitor with the state canal.

Location and Construction

The most important problem, after securing the charter and raising the initial capital, was to locate the route between Harrisburg and Pittsburgh. This was placed in the competent hands of John Edgar Thomson, who as chief engineer also built the road, and later, as president of the company, laid the basis of the engineering and operating organization, and directed its destinies with exceptional ability for 22 years. Many routes were studied, and especially the most feasible grade for crossing the Allegheny Mountains. Finally the valley of the Juniata was selected. Beginning at Harrisburg the route gradually ascended as it approached this mountainous barrier, and by the time it reached the city of Altoona it was 1181 feet above tide, from which point the actual ascent of the mountain began, and the crest was reached at Gallitzin, about 12 miles further west, where it crossed the mountain through a tunnel at an elevation of 2164 feet. The road made a gradual descent on the western slope of the mountain, passing through what later became important coal-producing and manufacturing centers on its way to Pittsburgh to reach to Ohio River waters, from which point the traffic at that time went by boat on to the Mississippi River. The maximum ruling grade westbound was about 1.7 per cent, and eastbound 1 per cent. The mountain section of the Pennsylvania Railroad, between Altoona and Johnstown via Gallitzin, was the last to be actively undertaken. It was finished in 1854, and the management announced that its railroad had been completed and equipped, and that a continuous journey by rail could be made from Philadelphia to Pittsburgh, although it involved the use of the state-owned road between Philadelphia and Lancaster and a short independent road from there to Harrisburg, both of which later came under the control of the Pennsylvania Railroad.

Purchase of the Main Line of Public Works of Pennsylvania

When the Pennsylvania Railroad had completed its line between Harrisburg and Pittsburgh in 1854, it soon became evident that the state-owned public works could not profitably compete with this new and improved avenue of transportation. The people of Pennsylvania renewed their agitation for the sale of these works,

which by an act of the legislature of 1857 were sold to the only bidder, the Pennsylvania Railroad, and it took possession August 1, 1857. One of the provisions of the act was that the Pennsylvania Railroad would thereafter be relieved of the payment of the unconstitutional tonnage tax fixed in the charter to prevent competition with the state canal. A bitter controversy arose over the question, which was finally settled in 1861 by the passage of an act commuting this tonnage tax, but which required the company over a period of years to pay over $15,000,000 for these state works, and instead of retaining the accumulated tonnage tax, which the company had not paid after 1857, it was required to use the latter to aid several separate branch roads which were later bought and merged into our system. The state-owned railroad between Philadelphia and Columbia was the only useful part of the properties purchased, and that had later to be fully revised and relocated. Of course, the Allegheny portage road was abandoned, as was its successor, the new portage railroad, which was a regular standard-gage railroad built by the state from near Hollidaysburg to Johnstown to supplant the inclined planes across the mountains. However, with the growth of our traffic, we utilized that part of the route of the new portage railroad from Duncansville to Cresson as part of the alternate double-track line over the mountains between Cresson and Petersburg, Pa. The canals were kept in operation in part for some years afterward, but as the railroad rates were gradually and continuously lowered, the canals could not profitably compete, so that through ice, floods, and general disintegration they gradually ceased to operate.

Western, Eastern, and Southern Connections

The long-haul carriage of the traffic to and from the Great Lakes and to and from the Ohio Valley and other parts even farther west seemed to have been the aim of those interested in the early development of transportation systems reaching the Atlantic seaboard, and the subsequent rapid development of the West proved the wisdom of this policy. Long hauls are still the key to profits if the load is large enough. The management of the Pennsylvania Railroad was just as aggressive as its competitors in this respect. It realized early that it could not stop at Pittsburgh and depend on short and weak western connections for traffic from that part of the country, but that it should if possible control several of the roads then built or in the course of construction extending toward Chicago, St. Louis, Cincinnati, and the Great Lakes. It accordingly extended financial aid to these western roads, which were able to push their respective lines to completion. This aid also took the shape of lending some of the iron rails from the new portage road for use on the connecting lines, which later were consolidated into what is known as the Pittsburgh, Ft. Wayne & Chicago Railway. The latter furnishes our principal entrance into Chicago and was leased in 1869 to our system for 999 years. Similarly, step by step the system west of Pittsburgh and Erie was created and linked together. It was found desirable in 1870 to create the Pennsylvania Company to assume their management, financing, leasing, and operation. In 1920, following the war and with the tremendous growth of our traffic in and around the Pittsburgh district, and the policy which had been followed of consolidating and leasing for so many years previously, it was decided that the operation of these western lines should be resumed by the Pennsylvania Railroad. As a result, the system is now divided into three operating regions: eastern, with headquarters at Philadelphia; central, with headquarters at Pittsburgh; and western, with headquarters at Chicago.

While making investments in these western connections, the company by no means neglected the commercial interests and the transportation necessities of the state of Pennsylvania and other adjoining states. It built many branch lines and also came to the assistance of a number of small roads which were in more or less embarrassed financial condition, but which were essential to carry mineral, agricultural, and manufactured products.

The line from Baltimore to Harrisburg and extending north from the latter city to Sunbury, Pa., was acquired in the 60's, and with it came control of the roads reaching the shores of Lake Ontario at Sodus Point, N. Y. The national capital was reached through an extension to Washington completed in 1872. The direct link from Philadelphia to Baltimore was acquired in 1881, and before many years the system was extended via the Delaware, Maryland, and Virginia peninsula to Norfolk.

The management was also mindful of the necessity of extending its interests eastward from Philadelphia to New York, and while it had arrangements for the movement of its traffic to and from New York City, they were not satisfactory as it was felt that they all should be under one control and management, and accordingly in 1871, what was known as the United New Jersey Railroad & Canal Company and its controlled lines were leased by the Pennsylvania Railroad. In this way the Pennsylvania Railroad permanently acquired its New York gateway and also the nucleus of that part of its system reaching the north and south Jersey seashore resorts.

Operating through the Civil War

It may be of interest to recall the results of operating the Pennsylvania Railroad itself through the Civil War. In 1860, the year before the war broke out, its total miles directly operated were 367, which does not, of course, include the western extensions. Its gross earnings in that year were $5,900,000. In 1865, when the war ended, the mileage it directly operated had risen to 856 miles, the gross earnings to $19,500,000, and the net earnings were also showing good results. The dividends during the war period rose from 6 per cent to 10 per cent, and following the war period fell back again to 6 per cent, but within a few years reached the 10 per cent basis again. In the same period several stock and scrip dividends were paid, the scrip being convertible into stock. These, however, did not represent water, but a portion of the large amount of surplus earnings which were put back into the property for its improvement instead of being paid in dividends. Practically all of the complaints that were so prevalent during the recent World War faced the railroads during the Civil War, such as shortage of labor (and this was so great during the Civil War that labor recruiting had to be done in Europe), higher costs of labor and materials, heavy taxes, and in addition non-specie payments of money, which disrupted our country during this great conflict between the North and the South. What is the secret that sustained the company through this Civil War period? I think it may be stated briefly as the ability to carry on its own business so long as it gave good service to the Government, and to adjust its charges for the traffic carried to meet the higher operating costs and taxes. The average earnings per ton-mile in the year 1865 reached the amount of 2.7 cents, and they fell from that figure almost continuously in every year until 1899, when the average earnings per ton-mile were 4.7 mills, due to the ruinous competition then affecting all American railroads.

Living through the 70's and 80's

It was our general experience that each decade produced a panic or depression, and about each five years we had a depression in business or finance. There always was a different underlying cause or explanation, but the panics and depressions came just the same.

The panic of 1873 (lasting pretty well up to 1879, and in this period I include the strikes of 1877 and the Pittsburgh riots) was the culmination of an exciting period of overexpansion, especially in the railroad industry. Over 30,600 miles of railroad had been built up to 1860, but from 1860 to 1865 (during the Civil War period) only 3300 miles of railroad were built in this country. From 1865 to 1873 new construction amounted to over 35,000 miles, so that at the end of 1873 over 70,000 miles of railroad were opened, which was far in excess of what the country required for its transportation needs at that time. There was not sufficient business to support the top-heavy capital structure of many of the roads, which, with the ruthless rate cutting and cut-throat competition, resulted in throwing about 20,700 miles of railroad into receivership in the period 1873 to 1877. Fortunately, the capitalization of the Pennsylvania Railroad was on a sound basis, and the company was not only able to weather the financial storm, but did not get below the payment of a 5 per cent cash dividend during these embarrassed financial conditions, and was able to increase this rate shortly afterward.

It is a remarkable fact that the territory laid out for our system by our predecessors over 50 years ago is, with few exceptions, the territory served by it today. Of course, it required vision and

foresight and the most serious consideration to do this, for no one man, or set of men, at any one time could have designed or ordered the creation of a system serving the territory between the Atlantic Seaboard and the Mississippi River, and the Great Lakes and the Ohio and Potomac Rivers.

I do not want you to get the impression that our system stood still even in the 80's. A railroad is never a finished product, and especially one like ours, located in the most important industrial centers of the country, which requires that millions of dollars be spent annually for additions and betterments and for the purchase of equipment and other appurtenances. While the country indulged in another period of rapid railroad building and expansion beginning in the 80's, our management continued to pursue the policy of gradual growth and acquisition of feeders even up to the year 1898, on the theory that the country should first catch up with the transportation plant which it already had. The long depression and financial embarrassments which began in 1893 and which had plunged many lines into receivership culminated in about 1898. In 1899 our management, having faith in the future of the country and the courage of its convictions, laid out an improvement program on such a large scale that it was often criticized for its boldness. The tremendous increase in the business of the country immediately following the adoption of this program proved the wisdom of the policy which the management had adopted, our gross revenues having about doubled in the period from 1899 to 1907, inclusive.

I must mention one part of this program which involved an expenditure greater than anything we had ever undertaken, and that was the decision in 1901 to build the tunnel extension into and through New York City, over to Long Island, and the construction of Pennsylvania Station in New York City. This was followed by building the New York Connecting Railroad, with its Hell Gate Bridge, thus connecting the Pennsylvania and New Haven systems, as well as the Long Island Railroad. As engineers you can appreciate the magnitude of this work, with two single-track tunnels under the Hudson River into Pennsylvania Station, and four single-track tunnels from the station to and under the East River, all to be electrified, and the extraordinary engineering problems that had to be solved. The management and the engineering profession had but little home experience to guide them in the building of standard-size railroad subaqueous tunnels to accommodate heavy and high-speed passenger traffic. In view of the importance and cost of the work, the management wisely created a board of eminent engineers to study the subject and supervise the preparation of plans, three of whom later had charge of the actual construction of the tunnel extension and station, working under the executive direction of Mr. Samuel Rea, then vice-president and later president of The Pennsylvania Railroad Company. This work was completed and opened for general operation in November, 1910. The station now accommodates over 40,000,000 passengers per annum. The New York Connecting Railroad and its Hell Gate Bridge were opened for passenger traffic in March, 1917.

KEEPING PACE WITH MODERN PRACTICES

Since then we have opened our extension into the city of Detroit, and completed the new Union Station in Chicago, in which we have a one-half interest. The World War, however, and the unsettled business and financial conditions following it, put a stop to large projects. While I say this, I must not overlook the fact that in the war period alone approximately $214,000,000 (about 19 per cent of the entire amount expended on all the railroads of the country) were spent for new construction work and new equipment on the Pennsylvania Railroad System to help win the war and make Government control a great success—if that were possible.

Our system has, in accordance with its earning capacity, continued to adopt modern practices in its road, yard, and shop operations, and is constantly studying new projects that lead to efficiency and economy of operation. We were not behind in this country in the field of long-distance standard-railroad electrification, for nearly 20 years ago we electrified one of our seashore roads from Camden to Atlantic City, and also a large part of the Long Island Railroad, and these were followed by the New York tunnel extension, which is electrically operated. In later years we electrified two of our main lines out of Philadelphia for suburban traffic. As far back as 1913 the electrification of our road across the Allegheny Mountains had been studied, and if railroad rates and profits had been more favorable we would have proceeded with this and other electrification projects and improvements long ago. In the same manner we have kept pace with motive-power developments; the tractive effort of our locomotives has grown from less than 10,000 lb. in the 50's to 90,000 lb. for our present large freight locomotives, and we have developed the simple Mallet locomotive with a tractive effort of 130,500 lb. We have also built several large electric locomotives, both for high- and low-speed service, and are rapidly developing their design so that when the time comes for us to install electric traction on our most congested lines there will be available electric locomotives of proven efficiency and adaptability for our service with a minimum number of types and a maximum standardization of parts as between the various types. The powerful engines and the larger-capacity cars, the 130-lb. rail, which, I may add, has been installed on the greater part of our main line, and the most modern signal devices, have been the means of keeping the American railroads in the forefront as the world's leaders in transportation. I may also mention in connection with rails the adoption of the 39-ft. lengths, although I well remember that many years ago we laid 60-ft. lengths on the West Jersey & Seashore Railroad for experimental purposes. With some hesitation I mention the automatic train-control device. It will find its own place in time when the proper system is developed, and in some cases it may be helpful where the latest type of signals have not been installed, but nevertheless there is more urgent need for grade-crossing elimination and other improvements that might well first proceed. Of course, improved shop machinery and tools are also in the picture, to which I may add the gasoline rail motor car, and the highway motor bus. They all are important features in the growth of a transportation system, for no railroad can do its full duty to the public unless it keeps abreast of the times with plant methods and practices of the most modern type.

THE ALTOONA SHOPS

Right here let me say that the Altoona shops are one example of the plant required by a modern railroad. They are the largest shops in the world for the construction and repair of locomotives and other equipment, and with the raw and manufactured materials and plant and machinery represent an investment of over $27,000,000. The works employ over 12,600 persons, whose payroll in August of this year amounted to over $1,500,000. The output of this plant consists of substantially three-fourths of the total locomotives required for the replacement of existing ones; one-half of the repaired locomotives required for the maintenance of the locomotive equipment of the system; one-half of the repaired passenger cars required for the entire system; and the making of all parts for locomotives, passenger cars, and freight cars used at all the shops and assembly plants throughout the system.

When it is realized that the equipment of the Pennsylvania System consists of 7300 locomotives; 270,000 freight cars, and 6800 passenger cars, and that this equipment, on account of its great size and the intensive way in which railway equipment is used in this country, handles as much business and earns about two-thirds as much money as the entire locomotive equipment of Great Britain, consisting of 22,000 engines, the plant's relative size compared with other railway shops throughout the world will be understood.

FINANCIAL

Speaking briefly from the financial side, of course it was the desire of the promoters of the Pennsylvania Railroad to build it through the sale of capital stock rather than to have recourse to bonded debt, so as to avoid receivership in periods of business depression and retain for the stockholders the steady earnings and equities of the property. They were successful to a marked degree, as they were able to complete all but the Mountain Division through proceeds from the sale of capital stock before it became necessary to sell bonds. With large earnings it obtained sound credit, and it buttressed that condition by pursuing the policy of spending the larger part of the earnings over fixed charges and dividends for betterment of the property and equipment instead of piling up its bonded debt. In fact, for many years the company

put as much of its surplus earnings back into the property for improvements as it paid out in dividends. Let the facts speak for themselves: Here is a property which represents an investment of $2,416,000,000 for road, equipment, and marketable assets. Against this there is a total issued capital at par of $2,116,000,000 outstanding, but the public holds only $1,545,000,000, the balance of $571,000,000 being owned by the corporations in the system, chiefly The Pennsylvania Railroad Company. This conservative capitalization is the principal reason why, when the net railway operating income is equal to only 4 per cent or less on the total property investment, 6 per cent dividends have continued to be paid. Little did our predecessors realize that the adoption of this sound policy of financing was to be so helpful in carrying the company through many depressions, periods of labor unrest, antagonistic legislation, Government regulation, the World War, and Government operation of the railroads, all of which have at one time or another placed a strain on our system that might have had serious results had not the capital structure been on a firm foundation. The World War, of course, seriously affected the Pennsylvania System, but if any person doubts the effectiveness and loyalty of the employees and the management, I would say that our system went into the Federal-control period at the end of 1917 with a net railway operating income of $77,800,000 and an operating ratio of 78.6 per cent; it emerged in 1920 with a net railway operating deficit of $62,700,000 and an operating ratio of over 104 per cent. In 1924 this operating deficit was converted into a net railway operating income of $84,000,000, with an operating ratio of 80.3 per cent, and the net is still climbing. Notwithstanding all of our difficulties, the company has never failed in any calendar year in all its existence, despite wars at home and abroad, floods, riots, strikes, etc., to pay a cash return to its stockholders, who now number over 146,500, representing citizens in all walks of life and their financial, educational, religious, and charitable institutions. It is such a sound vindication of citizen ownership versus either state or government ownership that "he who runs may read."

Corporate Growth and Subsequent Consolidations

I have tried to show in a general way the growth of our system, but few people realize the many ramifications of corporate growth. Our system originally consisted of over 600 constituent companies of all kinds—railroad, bridge, terminal, ferry, water supply, real-estate, warehouse, and electric-railway, which have been compacted and merged into 106 companies, of which 71 are transportation corporations, The Pennsylvania Railroad Company being the chief operating company. We hear much today of the necessity for railroad consolidations, and yet you will be surprised to learn that since the Transportation Act was passed we have found it impossible to effect consolidations and mergers or acquisition of small roads within our own system, even where we own all of the capital stock and operate these non-competitive subsidiary railroads. The view exists, which I think is mistaken, that the Transportation Act prevents all consolidations or compacting of such roads into a system until the Interstate Commerce Commission has adopted a railroad-system consolidation map which will group all principal lines of the country into a relatively few systems.

During this whole period of growth, the Pennsylvania Railroad, under that corporate name, has always remained solely a corporation of Pennsylvania, and by leases and stock ownership extends into other states and thereby controls the other roads forming the Pennsylvania System.

Results of Growth

It will be observed from what I have said that, while the main line of our road was in course of completion between Harrisburg and Pittsburgh, the management with almost remarkable foresight was really laying the outposts of our system in the West through control of various lines reaching that part of our country. The result speaks for itself, because in 1924 the system had 11,602 miles of first track and over 27,600 miles of all tracks, extending through 13 states and the District of Columbia, in which territory resides about half the population of our country. The investment in the property and equipment of our system is over $2^1/_4$ billions, and the gross earnings run about $700,000,000 per annum.

The following table will indicate its growth by 20-year periods in revenue ton-miles and passenger-miles from 1864 to 1924:

	1864	1884	1904	1924
Revenue ton-miles	436,591,940	4,134,657,237	14,223,451,129	41,920,099,245
Passenger-miles	163,094,736	512,873,485	1,218,521,705	6,386,432,558

It may also be interesting in this connection to show the relationship of the Pennsylvania Railroad System to all railroads in the United States, and the following statement will indicate the extent of our system's activities compared with all of the railroads of the country:

	Per cent
Miles of road	4.95
Miles of track	7.09
Investment in road and equipment	10.21
Revenue ton-miles	11.82
Passenger-miles	17.27
Number of employees	13.18
Operating revenues	12.20
Passenger-equipment cars	15.16
Freight-equipment cars	10.96
Locomotives	11.74
Tractive power of locomotives	13.55

Future of the Railroads

Its growth and service are not at an end, but future expansion may not necessarily be in the direction of opening new territory, as the eastern section of the country is now pretty well gridironed with railroads, highways, and motor service. The demand for vigilant management to secure greater service and facilities is here, and the traffic must be carried at continuously lower costs to earn satisfactory profits, and pay fair returns to the owners, as well as leave a margin to protect railroad credit. Future capital expenditures in the East will probably be for intensive development on the existing lines. Provided the railroads are allowed fair returns, the improvements will be in the enlargement of terminals, yards, and their equipment, with the introduction of the best labor-saving devices, the construction of additional main- and branch-line tracks, rebuilding and strengthening bridges, and the purchase of the most modern equipment, the plans for which will test the skill and resourcefulness of the engineering profession. In these days of severe competition the railroads must produce the maximum of transportation with the minimum of expense, and the use and improvement of the freight car and engine must be so planned as to bring about this result; large projects of electrification are in sight, and with big power plants fed by water or coal, or both, the farmer's boy, as well as the millionaire, may yet drive his plow, heat his house, and toast his bread with electric current at little more cost than by the raw products of coal and wood. The gasoline rail motor car and the Diesel-electric engine, using oil or gas for fuel, must also be considered for they are fast coming to the forefront, and in the field of railroad operation, long runs without change of engines or cars will shortly be the rule and not the exception.

The people of the United States want their railroads to be able to give the best service; the railroads want to give that service and to continue the leadership of the world with the big train load with the lowest freight rates and the highest justifiable wages for their employees, and at the same time pay fair returns to their stockholders; but the test is, will the people generally be willing to let the legislative and regulatory bodies clearly appreciate their wants and also their willingness to pay rates to justify such a forward program, and eventually resume the lower costs of the years preceding the European war?

I leave some figures with you on another angle of the situation entirely aside from the public train service which the railroads perform, and let you be the judge of the importance of their contribution to the nation's welfare. Few people take the time to reflect on the vast purchasing power of the money the roads disburse annually, and it may interest you to have some of these figures for our system alone. Last year our payroll amounted to nearly $360,000,000; we paid approximately seventy-five millions to our stock and bondholders; we spent over seventy-seven millions for materials and supplies; our fuel bill was about thirty-eight millions,

and we paid over thirty-three millions in taxes. To lessen the capacity of the railroads to make these disbursements cannot help but harmfully affect our natural economic structure, the many thousands who are dependent on the railroads for employment, and those whose only income in many cases is represented by the returns received from small security holdings.

CONCLUSION

Few people can appreciate the tremendous task it was to build our system up to its present size, step by step, and I do not want you to get the impression from this review of its growth that its pathway was strewn with roses, for it has run the gauntlet of wars, strikes, riots, floods, fires, hostile regulation, and a rate structure that at times practically amounted to confiscation. However, with an intelligent and progressive board of directors, a well-trained and efficient body of officers and employees, and a loyal body of stockholders, we have been able to survive many difficult periods. I believe we are on a firm foundation today, and with reasonable rates, relief from excessive taxation and extraordinary demands for grade-crossing elimination and palatial passenger terminals, and an opportunity to operate the railroads free from regulation that paralyzes initiative and dictates management without responsibility, it is my opinion that not only our system but all of our railroads will continue to grow and retain their commanding position, which means so much in assuring the prosperity of our country.

The Railway as an Economic Force

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WE ALL need to pinch ourselves every morning to remind ourselves that we are citizens of a new economic society created almost overnight. For, seen in historical perspective, it was only last night that man discovered coal. It was early this morning before he tilted the first crude steam engine over on its side, put wheels under it, and made the grandfather of the steam locomotive. It was only at breakfast time that he began to use this same steam engine to run looms, spindles, and other machines which enormously increased the production which could be managed by a single person. And yet before noon, out of all this a new economic civilization had been created. The number of people who can be kept alive at one time has been doubled in a scant hundred years. We have all been so busy trying to keep up with the increases wrought in man's productive power that only lately have we begun to discover a few of the fundamental rules that govern the health of this new scheme of existence.

Its dependence upon railroad transportation, for instance, cannot be overstated. Each year now a ton of freight must be hauled over 4300 miles for every man, woman, and child in our country. This is ten times as much transportation per capita as is required by European civilization, and three times as much as we ourselves required only twenty years ago. If all this vast horsepower on which we are so dependent were embodied in living horses, then even the children would understand that the care and conservation of horses was a matter of life-and-death concern. A good citizen would be one who was intelligent, careful, and considerate with horses. Certainly no party would expect to rise to the leadership in such a society on a platform of daily abuse of horses, skimping their feed, denying them new shoes, and occasionally mixing a little poison in the water which they are going to drink.

The fact that this vast horsepower is locked up in the iron and steel of railway facilities does not affect these essential truths one iota. But it does succeed in hiding from a vast multitude of modern people truths which they would recognize if envisaged in less complicated forms.

Again, the vast aggregate of their work in the course of a year has given to our railroads a most important place in the structure of modern economic society. They have become the great customers of its basic industries. They will take a third of the coal output; a quarter of the lumber output; a third of the steel output; a half of the fuel-oil output, and a substantial proportion of the products of practically every other basic industry in the country. Between the workers who produce these things which the railroads must consume and the workers upon the railroads themselves, one family out of every six or seven is dependent upon the railroads for its income and standard of living. All of this is in addition to the life-insurance policies, the industrial-insurance policies, and the savings-bank accounts in this country, at least one-fifth of the assets behind which are railroad securities.

So it comes about that you can no longer give employment to the people in this modern society—you can no longer distribute consuming power to the people of the United States—except upon the condition that the railroad industry receives its fair share of the national income.

All that we connect in our mind with the general phrase, the modern railroad problem, can be summarized in a single sentence. It consists of the fact that for over a generation prior to the European war, the railroads had been gradually and progressively denied their fair share of the national income—that share which it would have been in the interest of every producer and every consumer for them to have received. Instead of this, for over twenty years freight rates had been permanently and progressively held below the rising values of labor and commodities.

Then came our entry into the war, followed by a great enlightenment. Millions woke up to the fact that the country would have been far better off had it previously allowed its railroad industry more adequate revenues. And so after twenty-six months of Federal control the railroads were returned to their owners, accompanied by the Transportation Act. This asserted for the first time in our history a fundamental law of economic health—that there is a national public purpose to be served by giving to the railroad industry its fair share of the national income.

But the practical situation was more difficult. The outstanding effect of the war had been an enormous increase in every element of cost in the production of railroad transportation. In 1920 the labor cost of moving a ton of freight was more than the whole rate was in 1915. Despite an increase in rates, the increase in every element of cost was at least twice as great. In other words, there was a gap of 50 per cent between the increase in the costs of producing service and the increase in what could be charged for the service.

This gap can be bridged only by a great increase in the intensity and efficiency in using the tools of transportation. The amazing thing is that in five years this gap has been almost bridged. It has required the investment of more than three billions of new capital. It has required the purchase of over 600,000 new freight cars and over 10,000 of the newest and most powerful locomotives. These new freight cars have pushed off the rails older cars which could not hold so many tons. These new locomotives have supplanted older locomotives that could not haul so many cars in a train. An enormous nation-wide effort has been made to increase the load of each car and to decrease the time consumed in loading and unloading. And so gradually we have gotten six more cars in the average freight train; a couple of extra tons in the average freight car; while locomotive runs have been approximately doubled. Thus the higher cost of moving a train has been spread over a greater volume of tonnage and this tonnage has been hauled a greater number of miles, resulting in the reduction of the incidence of these costs on each ton-mile of transportation. One of its minor economies is to be found in the fact that we will burn 18 million less tons of coal in our locomotives during the present year than were burned in 1920, while at the same time our actual movement of commodities will be greater.

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But perhaps the most revolutionary effect of this raising of the plane of railway operation is found in the conduct of the economic life of the country. Beginning in 1923 we gradually cut the average time in transit nearly in half. As a result, producers could carry on a given volume of production with a smaller accumulation of raw material in advance of manufacture, and a smaller stock of manufactured goods in advance of consumption. Wholesalers and retailers could swing a given volume of business with smaller stocks. In short, an enormous amount of industrial and mercantile capital of the country has been made and kept liquid.

For instance, a few weeks ago the head of a big copper company examined the records of some 200 cars of ore in one of its plants. He found that their average time in transit had been reduced from 27 to 13 days, and that the saving in interest alone due to expedited service went a long way toward paying the entire freight bill.

In 1920 the Ford Motor Car Company carried in transit and in its plants materials and supplies for 60 to 90 days. Today these plants are operating on a five-day supply and the new one at Pittsburgh is attempting a day-to-day assembly direct from the incoming car.

The head of one of the leading department stores in St. Louis recently said that in 1923 his company had a million dollars less tied up in stock while doing considerably more business. The saving in interest on this greatly reduced inventory has been sufficient to pay the entire freight bill of this concern for the past two years.

The money value of good transportation to business has been analyzed in the case of the lumber industry by Charles I. Keith, president of the Central Coal & Coke Company, of Kansas City. In a letter to Carl R. Gray, president of the Union Pacific System, Mr. Keith discusses the situation:

> I wonder if you and others in the railroad fraternity know what you are doing to the manufacturers. It now takes ten days to move a car from point of origin to destination where formerly it took fifty days. The result is that the retailers throughout the country have been running their stocks down to the vanishing point and we find instances where the retailers are clubbing together and buying in mixed cars to fill their joint requirements.
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> The average retailer in Missouri, Kansas, and Oklahoma is anticipating his requirements only eleven days in advance. In Texas the rule seems to be seven to nine days; in Chicago twelve days to three weeks, depending upon the territory from which the shipment is to come; all of which means that they are taking advantage of the saving in transit time and have reduced their stocks to a very low minimum.
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> It is estimated that during the last three years the stocks through out the country have been reduced to such an extent that such reduction has been equivalent to 12½ per cent increase in production of lumber in the United States. At least, that much more lumber has been available than otherwise would have been.
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> Furthermore, this means that approximately $600,000,000 have been taken out of stocks and accounts in the lumber industry since 1923. As lumber only contributes 8½ per cent to the car loadings, it is fair to assume that at least 50 per cent of the apparent saving of $7,000,000,000—or $3,500,000,000—has been saved to the industry in the United States. Of course this figure does not take into consideration the saving in interest. It has had, however, a great effect on the money market through the piling up of money in the banks.

These facts will give you some idea as to why Secretary Hoover cites the railroad industry as the outstanding example in the elimination of industrial waste. Secretary Hoover recently said:

> I can perhaps illustrate what we mean by "elimination of industrial waste." We have had a fine demonstration in our railways during the last three years. During this period our railways have handled a 14 per cent increase in freight at no material increase in gross operating expense. There has been a decrease in rates of over 5 per cent, the hours of the workers employed have diminished rather than increased, and the wage has slightly increased. Further, service to the community has been immeasurably improved.
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> The great national losses of a few years ago by car shortages and their resultant strangulation of commerce and industry, with the inevitable inflation of prices and the speculation which flowed from it, have been largely eliminated.
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> These savings are just as important as economy in government. They mean just as much to the taxpayers' pocketbook as reduction in taxes. Their results do not come about by personal self-denial or deprivation. As a matter of fact, in result we are able to secure more joys in railway transportation for less expenditure today than three years ago.
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> This has been accomplished by great effort in management, by great coöperation between all units of our transportation machine, by efforts of the employees, by organized coöperation of the community itself.

I trust that most of you already know that the railroads have definitely organized continuous coöperation with shippers. We now have eleven shippers' regional advisory boards in this country covering all but one of its natural economic territories. The heart of these boards is a series of committees representing producers and distributors of every important commodity. From these commodity committees we receive estimates, from two to six months in advance, as to what the production and distribution of the commodity is going to be in that particular territory. This information is used very much like the general staff of an army, to mobilize the entire car supply of the country. But this has been only the beginning. Thousands of important railroad men have been given an insight into shippers' problems. Thousands of the most important shippers and distributors have been given insight into the railroads' problems. Both have coöperated to take out of their respective sides of the picture practices and failures which reduced the efficiency of either industrial plant or railroad. In the end we are warring on economic waste, because wherever found it is our common enemy.

I often feel that our people would make much more rapid progress toward an understanding of their stake in adequate railroads and adequate railroad revenues if we could only break down the curious and grotesque obsessions which have been built up with regard to freight rates. The cost of moving long distances bulky products of low value is of course high. In no other way could the railroads serve as the conduits of those economic forces which prescribe the economic location of production and distribution. But on things of universal human consumption freight rates are unbelievably cheap. There is hardly a pound of food which passes over the table of an American family on which the freight rate is as much as a cent. We haul a dozen oranges up from Florida for two cents and bring eggs clear across from the Pacific Coast for less than three cents a dozen. The freight rate on a pair of shoes shipped 300 miles or more is only about five cents and on a suit of clothes the same distance only about six cents. Rates on these commodities could be increased 50 per cent or decreased 50 per cent and the consumer would never know the difference. The only difference would be between railroad adequacy and railroad bankruptcy.

Even on manufactured articles railroad transportation is unbelievably cheap as contrasted with other forms of transportation. For instance, we will haul a piano from Chicago to New York for about $15. You couldn't move that piano twenty blocks in New York City for the Chicago-to-New York rate.

If the traffic manager of a responsible enterprise comes into a railroad man's office and says that there is something out of line with regard to some freight rate, we will all assume that there is something there which requires investigation; but when the politician and the demagogue talk about freight rates it can safely be said that they do not know what they are talking about and have not as yet attained the first understanding of what is the real cause of the maladjustment, whatever it may be.

Thus we have been hearing for the past four years numerous plans to improve the farmer's condition by decreasing the freight rates to market his commodities. Nobody seems to have stopped to inquire who pays those freight rates, the farmer or the consumer of farm products. Very few have stopped to inquire whether the farmer's outcome is not determined when he lays his freight alongside the door of a car; and whether this outcome is not the result of what he chose to produce and what it cost him to produce it.

Have you stopped to think that a little haul at each end of a long haul on a railroad may cost three times as much as the whole rail charge? Thus I knew a publisher who joined with a number of his associates to get a 10 per cent reduction in a rate of 37½ cents a hundred pounds on his newsprint paper—and yet for five years, without a word of protest, he had been paying 50 cents a hundred pounds to have that paper trucked less than a half a mile from the railroad car to his printing plant!

If we are going to get out of modern economic society the great material benefit which can be got, we shall all have to become much more intelligent in our understanding of fundamental economics. In promoting this understanding there is no more important person than the educated engineer, whose training and inclination alike incline him first to ascertain the truth, and then to abide by it and to make it prevail.

The Charles T. Main 1925 Prize Award Paper

The Influence of the Locomotive upon the Unity of Our Country

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There are three things which make a nation great and prosperous: a fertile soil, busy workshops, and easy conveyance of men and commodities from place to place.—Lord Bacon.

EVER since the day of the *Stourbridge Lion*,[2] the first locomotive to run in America, the locomotive has been one of the greatest factors in establishing unity in the United States. It is not necessary to recount here the quite familiar, yet very interesting, story of the invention and development of the locomotive. As to its introduction into America, however, it is well to remember the date, 1829, and the fact that the first locomotives built in America were not dominated by English ideas, as is often supposed.[3] They were purely original developments of characteristic American ingenuity, and it was these locomotives that blazed the trail of civilization across the continent.

A study of the influence of the locomotive upon the unity of America can be conveniently divided according to three principal types of national unity. First, the locomotive has had a tremendous effect upon the history, political thought, and government of the United States. Second, its influence upon the industrial, commercial, and financial life of the nation is very great. Third, the social relations and ideas of the people and their language have been affected to a large extent by the locomotive. This paper will therefore be developed under the three types of unity, namely, political, economic, and social, all of which together constitute the unity of our country.

The influence of the locomotive in our national development can best be understood after a short outline of the development of the railroad system in America has been presented. The principal periods in American railroad history are:

1 *Experimental Period* (1830–1850). Railroads short and disconnected. Served principally as connections between waterways with no apparent objective.

2 *Trunk-Line Period.* (*a*) From 1850 to Civil War. Trunk lines created, connecting Chicago and Mississippi with Atlantic. Much construction in old Northwest Territory and consequent network effect. (*b*) From Civil War to 1890. Transcontinental lines built, uniting East and West. Improvement of old lines.

3 *Period of Combination* (1890–). Great combinations formed. Government regulation. Great development. Better coöperation and organization.

In this manner the "railroad system" of the United States has been formed and unity has been developed in the railroad itself.

The Westward Progress of the Railroad

Buffalo from Albany	1842
Cincinnati from Lake Erie	1851
Chicago	1854
Mississippi River	1859
Missouri River	1859
Pacific Ocean	1869

Political Unity

The political unity of a nation is best measured by its transportation facilities. Its expansion, development, and its organization into a united nation depend to a large extent upon the ease of communication within its borders. Especially has this been true in America, for the locomotive has been the greatest single factor in shaping the history of this great nation. It first developed the settled seaboard and Middle West, then pushed the frontier westward to open up new territory and to add new states to the Union which it had preserved in its hour of need. The locomotive has influenced the shaping of national political thought and the formation of a strong national government, while it has been continuing its work so that now every community is united to every other community with ever-increasing bonds.

At the close of the first quarter of the nineteenth century there was no country in the world where the opportunity for benefits from transportation was so great as in America. The growing commercial cities of New England and the Atlantic States needed better transportation facilities. New states had been formed west of the mountains which demanded communication with the East. Beyond them stretched the vast Louisiana Territory of untold resources. The South, too, was expanding, and wanted inland connections with New England and the West. There was much enthusiasm for the building of canals and turnpikes, but withal, transportation facilities were very poor.[1] Indeed, the East, South, and West threatened to be developed individually as separate national states.[2] Such was the situation when the locomotive suddenly appeared on the horizon to solve the problem.

The first function of the locomotive in America was to provide easy and cheap transportation in territory already well settled. It united inland cities and towns with the seaports and brought the products of the fertile Ohio Valley across the mountains to the East, bringing manufactured goods in return. In performing this work the locomotive has further developed and organized the country. Especially was this true in the "Old Northwest"[3] where the opportunity was greatest. Development of this nature was but little shared by the South until after 1880.[4] With the formation of new states in the West this function has continued to be performed admirably by the railroads in developing national unity.

Gain in Population, East and West, from 1815 to 1860

	1815	1860
East	5,800,000	15,806,000
West	1,500,000	15,484,000

Railroad Mileage by 1860, East and South, and Northwest

East and South	19,506
"Old Northwest"	9,413

Note.—Mileage in the South increased from 20,600 in 1880 to over 50,000 in 1900.—Alexander Helper, op. cit.

A more important function of the locomotive, however, and one which is peculiar to America, is that of advancing the frontier and developing new territory into new states. This has been the chief task of the locomotive beyond the Mississippi. Here it is noticeable that the locomotive preceded the pioneer, as the pioneer preceded the immigrant. Lines of travel were "destined to be along parallels of latitude,"[5] and under the influence of the locomotive the frontier moved rapidly westward until, with the completion of the last transcontinental railroad in 1884, it suddenly disappeared forever.[6] The tremendous resources of the Great Plains and the Far West[7] had been opened up to the world, but the task of the locomotive was not finished. It now transformed this vast territory

[1] The Catholic University of America.

[2] The *Stourbridge Lion* was imported from England and ran on the timber rails of the Carbondale Railroad, Aug. 8, 1829. See Wm. H. Brown, History of the First Locomotives in America.

[3] See Angus Sinclair, Development of the Locomotive Engine.

[1] See Charles L. Raper, Railway Transportation, chap. XII.

[2] Frank L. McVey, Railway Transportation; Some Phases of Its History, Operation, and Regulation.

[3] The "Old Northwest" is the term used by Prof. Frederic L. Paxson to include Ohio, Indiana, Illinois, Michigan, and Wisconsin in his book, The Railroads of the "Old Northwest" before the Civil War.

[4] "The South of today owes her activity and advancement chiefly to the railroads."—Alexander Helper, in Railroads, Their Relation to the Farming Interest, Industrial, Manufacturing and Commercial Development.

[5] John S. Bassett, Short History of the United States, p. 733.

[6] See Frederic L. Paxson, The Pacific Railroads and the Disappearance of the Frontier in America.

[7] "The growth of the Far West was dependent upon railroads."—John S. Bassett, Short History of the United States, p. 680.

from a wilderness into a thriving land of cities, towns, and farms within less than a century. Its objective in this work has been the formation of new states. Probably the formation of none of the states east of the Mississippi can be accredited to the locomotive since most of them had been formed prior to its importance; but certainly many of the states west of the river owe their present existence directly to the locomotive.

RAILROAD MILEAGE BY SECTIONS OF THE COUNTRY, 1860–1890

Section	1860	1870	1880	1890
New England	3660	4494	5977	6832
Middle Atlantic	6353	10577	15147	20038
Central Northern	9583	14701	25109	36926
South Atlantic	5463	6481	8474	17301
Gulf and Mississippi States	3727	5106	6995	13343
Southwest	1162	4625	14085	32888
Northwest	655	5004	12347	27294
Pacific	23	1934	5128	12031

The influence of the locomotive upon the Civil War cannot be overlooked. It is no exaggeration to say that the locomotive preserved the Union. There was twice as much mileage of better-organized and better-equipped railroads in the North than in the South, which was of importance in the moving of troops, ammunition, and food. The factor of most importance, however, was completed before the war. During the decade preceding the struggle the locomotive had united the people of the Ohio Valley with those along the Great Lakes, and these in turn with those of the East, an accomplishment destined to be the deciding factor in the coming crisis.[1] Thus the locomotive was of great aid in winning the war[2] and in preserving that Union to which it has since added many states.

Not only has the locomotive created a large and populous nation, but it has united the people of that nation with ever-increasing bonds. It is eradicating sectionalism in political thought and is making Americans of all. It has been very influencial in making our government national in character. In fact, it makes representative government successful because it permits extensive personal political campaigns and easy communication between the representative and his constituents.

POPULATION AND RAILWAY MILEAGE IN 1860

	Population	Mileage
North	20,310,000	20,274
South	11,133,000	10,352

The locomotive has had a tremendous influence upon the political unity of America. It has been seen how the locomotive has developed America into a united nation, an accomplishment which would have required centuries without its influence, and which never could have been accomplished so thoroughly. The test of its work came with the World War, which found America united and ready, and its railroads able[3] to play an important part when acting as a single unit. The locomotive was unquestionably proven, but its work was not finished, for it is still continuing to establish further unity in our country.

ECONOMIC UNITY

The locomotive has brought economic unity to the United States. The nation is not made up of many isolated areas, with no economic connections between them. Instead, under the influence of the locomotive, America's great natural resources have been developed and her products have been distributed over the entire land, so that a well-organized economic system now exists.

The presence of remarkable natural resources in America is well known and transportation facilities have formed the basis of their development. "This is preëminently and primarily an agricultural country."[1] In the development of its agricultural resources the locomotive has played an important part, especially in the opening up of the grain lands of the Ohio and the Mississippi and the grazing lands of the Great Plains and the Southwest.[2] America has rich mineral deposits, but it is the locomotive that makes their extraction profitable. The enormous production of the ores of Lake Superior and the Rockies, the coal of the Alleghenies, and the oil of Oklahoma is due in a large measure to cheap transportation. Timber is another important resource of the United States, and the locomotive has been a vital factor in developing the lumber industry of both the Old Northwest and the New Northwest, as well as that of the South. These are but a few of the many natural resources of America, all of which owe much of their development to the locomotive.

It is in the field of transportation that the locomotive has had its greatest influence upon the economic unity of our country. Easy and cheap transportation has increased the area of production of every commodity so that it can now be produced profitably at a great distance from the market as well as near-by. It facilitates the gathering together of the raw materials from all parts of the country to the centers of distribution and manufacture. Modern transportation permits the localization of industry near the source of supply or at points best suited for the manufacture of a particular article. The locomotive has widened the market of every commodity produced in the land, and serves, by encouraging competition, to distribute the products to every community of the nation.

In the development of our natural resources and the creation of industry, the locomotive has created commerce in the United States.[3] Commercial centers have been created and developed at centers of distribution, such as railroad centers, and at points of change from one means of transportation to another, such as seaports. By its very nature, railroad development encourages development in other means of transportation. Thus the commerce of America has been built up until it has reached tremendous proportions, and the locomotive has been one of the greatest factors in its development.

Labor is needed in commerce and industry and the locomotive is a vital factor in supplying the demand for it. It permits a wide distribution of labor and supplies easy and quick transportation of labor from place to place as needed. It also supplies a market for various kinds of labor. The locomotive has facilitated immigration by transporting the immigrant to new lands where his labor is most needed. It is noticeable that the number of immigrants increased tremendously with the advent of the railroad.[4] The locomotive has helped to make the standards and conditions of labor uniform throughout the country. In this manner labor has become a united force to serve the nation's industries.

Another field of economic importance in which the influence of the locomotive has been felt is that of finance. The locomotive has not only created and developed wealth, but it has also influenced its distribution. The development of corporations for financing large-scale operations came with the locomotive. It also aids in the distribution of money and facilitates its movement from place to place,[5] thus tending to prevent panics. It enables business enterprises to operate over a vast territory with ease. The railroads themselves form a very significant part[6] of the total wealth of the

[1] See Frederic L. Paxson in The Railroads of the "Old Northwest" Before the Civil War.

[2] "Through the railroads of the country, the conquest of the South by the North was effected and Slavery abolished." Theodore D. Jervey in The Railroad, The Conqueror. In this booklet Mr. Jervey states that a proposed railroad from Cincinnati to Charleston might have both solved the slavery question by introducing free labor in its construction and so united the South and the West as to prevent the conflict. Although Robert Y. Hayne was president of the road, John Calhoun, at first one of its directors, opposed its construction in so vigorous a fashion that it never was completed.

[3] "It is not too much to say that the fate of the world in the critical year 1918 hung upon this tremendous railroad system which the enterprise and genius of Americans had built up in three-quarters of a century." Frank L. McVey in Railway Transportation: Some Phases of Its History, Operation and Regulation, p. 240.

[1] James J. Hill, Highways of Progress, p. 15.

[2] The gain in grain production from 1866 to 1878 was more than twice as great as the gain in population in the same period. In the last half of the last century 547,640,932 acres have been added to the agricultural area of the country.

[3] "The railway in America has preceded commerce." Frank L. McVey in Railway Transportation: Some Phases of Its History, Operation and Regulation.

[4] The immigration by decades from 1820 to 1890 was as follows:

1821–1830	143,439	1841–1850	1,713,251
1831–1840	599,125	1881–1890	5,246,613

[5] Particularly under the Federal Reserve System.

[6] Charles L. Raper states that the finances of the railway system involve as much as one-eighth of the total wealth of the nation.

nation, of which the locomotive has been an important factor in developing.

"The effects of railroad construction are far-reaching."[1] It is hard to overestimate the influence of the locomotive upon the development of our natural resources, industry, commerce, labor, and finances into a well-organized economic system. Certainly it may be said that this, the economic unity of America, owes much to the locomotive.

SOCIAL UNITY

The locomotive has been very influential in the development of social unity in America. In fact, the history of the locomotive is closely allied with the modern development of civilization.[2] Better communication has brought better understanding and knowledge between peoples and is doing away with sectionalism in social thought and placing national social unity in its stead. The locomotive is of great aid in relieving suffering in time of distress. Modern travel has become a pleasure in itself. All these tend toward national peace, prosperity, and happiness, and in this the locomotive is an important factor.

Modern civilization has advanced farthest in those places where the locomotive is seen most often. The locomotive is its keynote, for it introduces modern art into the community. It encourages religion, education, and good government, while it is noticeable that bigotry, illiteracy, and lawlessness are found where railroads are not. The locomotive promotes progress in civilization among the people.

Better communication as afforded by the locomotive has several effects beneficial[3] to a greater social unity in our country. The locomotive enables peoples of different communities to become better acquainted with one another. The customs and manners of one become better known and understood by the other. One of the greatest means of accomplishing this end is the "convention," which itself has been made possible to a great extent by the locomotive. Every year thousands of people are gathered together from all parts of the country in various places. Although various fields of endeavor are represented and many ideas are exchanged, it is the social contact at these conventions that does the most to promote a better understanding between peoples and communities.

Not only does better communication encourage better knowledge of society, but it tends to unite society in America with national bonds. Through better acquaintance, ideas, customs and manners, and views on common problems are exchanged, with the result that national ideas, national customs and manners, and national views are developed. Religion, education, and government become national in character. The locomotive is preventing and eradicating the growth of dialects in America and is thus establishing a common language. Because it is the mail carrier of the nation and sends and brings the messages of the people, the locomotive provides a cheap form of communication which is an important factor in the development of social unity. The nation is united even in its emotions, for the mourning of the death of a president is as spontaneous as the celebration of the announcement of peace.

The locomotive is of great aid in times of distress. A flood on the Ohio, a tornado in Kansas, a fire in Chicago, or an earthquake in San Francisco, and the locomotive immediately rushes aid from all parts of the country to the distressed sufferers. A famine in any locality is nowadays almost impossible, for the locomotive soon relieves a shortage in any commodity, no matter what the season may be.

Modern conveniences have added to the work of the locomotive to make modern travel a pleasure. One is now able to visit all parts of the country with ease and comfort,[4] and at little expense. By this means the locomotive enables the citizen to obtain a broader knowledge of his native land and at the same time to enjoy her beauties. Thus the locomotive is not only able to relieve man of his sorrow, but it has added new pleasures to increase his contentment in America.

No country in the world is as prosperous as America. Its people have an abundance of food, clothes, and wealth, and comfortable homes in which to live. They are happy and peace reigns among them. The locomotive has had a tremendous influence[1] in bringing prosperity and contentment to America. Truly, as James J. Hill has said, "The railway, next after the Christian religion and the public school, has been the largest single contributing factor to the welfare and happiness of the people."[2]

Modern transportation is a great benefit to society. It develops its civilization, increases its scope, knits it together more firmly, relieves its sorrows, and adds new pleasures for its enjoyment. It promotes prosperity and contentment among its members. The locomotive, which has made cheap and easy communication possible, has thus been a vital factor in establishing social unity in America.

CONCLUSION

It is just a century and a half since the Union had its humble yet determined beginning. With less than a century of existence the locomotive has had a tremendous influence in the accomplishment of a great and unparalleled achievement. Not only has the Union been increased, the national domain extended, and the population multiplied many times, but the nation has wealth and her people are prosperous and contented. But above all, the locomotive has given political, economic, and social unity to America. It is recognized, however, that these three types of unity are by no means entirely separable. In fact, they are quite inseparable, for each one is involved in the other two to a great extent, and it is only when taken together that they make up the unity of our country.

Today a network of railroads covers the United States. Every community is united to every other community with bonds of steel. As to the future, the locomotive can be confident of more than holding its place in transportation. No other means of transportation can compare with the locomotive in efficiently supplying cheap and quick transportation of goods and men wherever needed. Just as past experience has shown the locomotive to exceed all expectations,[3] so for the future it is safe to say that the locomotive will continue to be of the greatest influence in preserving the unity of our country.

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[1] Frank L. McVey in Railway Transportation: Some Phases of its History, Operation and Regulation, p. 12.

[2] Rufus H. Sanford in The American Locomotive, 1829–1897.

[3] See Dr. G. W. H. Kemper, The Railroad as a Benefactor in Civilization.

[4] "The poorest citizen travels in greater splendor than the monarch of fifty years ago." Marshall M. Kirkman in The Relation of the Railroads of the United States to the People and the Commercial and Financial Interests of the Country, p. 6.

[1] "It affects more nearly and vitally the prosperity and comfort of a community than any other interest, than indeed of the government itself." Marshall M. Kirkman in The Relation of the Railroads of the United States to the People and the Commercial and Financial Interests of the Country, p. 6.

[2] James J. Hill in Highways of Progress, p. 237.

[3] See the prediction of Dr. Anderson, a friend of Watt's, made in 1800, as quoted by Wm. H. Brown in History of the First Locomotives in America, p. 37.

Commercial Cylindrical Lapping

A Cylindrical Lapping Machine and Its Operation—Production of Piston Pins—Tolerances—Conservative Rate of Commercial Lapping—Work Holders—Truing Lapping Wheels—Lapping Experiments and Conclusions Drawn Therefrom

By C. T. APPLETON,[1] WORCESTER, MASS.

MANUFACTURING is entering into an era of quality. Quantity production has been outstanding for many years, but now in order to meet the more cautious demand, we must have "production with quality." This gives a low cost and more durable commodities.

The automotive industry offers a good illustration. Increased durability of automobile parts has necessitated the extensive use of hardened-steel parts requiring ground surfaces to supplement the turned and milled surfaces which have previously been satisfactory. However, the progressive car builders have now generally accepted the lapping of many parts as standard needed practice, and will continue with only this method of finishing when mechanically possible.

Lapping actually obtains a good bearing surface prior to the using of the parts. The engineers of one of our largest automobile factories state that lapping adds ten thousand miles to the life of piston pins.

A Cylindrical Lapping Machine and Its Operation

The introduction of the Mirra cylindrical lapping machine offers a method of commercial cylindrical lapping on a production basis.

The right side of this machine is shown from the operating position in Fig. 1. The upper wheel is raised and a work spider full of piston pins is shown in position for convenient removal. Fig. 2 shows the left side of the machine with the work spider removed. The machine has two wheels located on vertical axes and independently driven from a pulley shaft at the rear. The wheels are located in separate heads on an extra-heavy column. The lower wheel has no vertical adjustment in its head, while the upper one slides vertically. The vertical movement of the upper-wheel spindle is controlled from a pilot handwheel and a handwheel spring mechanism. The pilot handwheel provides for bringing the upper wheel quickly on to the work, and then the handwheel spring mechanism is engaged, allowing a heavy pressure to be placed by the upper wheel on the work with the minimum amount of effort on the part of the operator.

To simplify the illustrating of the method used, we shall take for example the lapping of automobile piston pins. The method consists of placing a number of piston pins loosely on a quick-loading work spider which is located between two lapping wheels. Both wheels rotate in opposite directions at a slightly different speed.

Fig. 1 shows the work spider in the loaded position with the piston pins resting on the lower wheel. When lapping, the upper wheel is brought down on to the piston pins under pressure, and the variations in work supplied cause the pins to rotate between the lapping wheels and creep slowly in a circular path in the direction of the faster wheel.

The projecting arms on the work spider are not radial with the center of the spider, thereby causing the piston pins when rotating to have a rotating sliding action between the wheels. The center of the spider rotates eccentrically with the center of rotation of the wheels, thus giving three distinct actions of the work in the wheel, namely

1. The creeping of the work caused by the variation in wheel speeds
2. The sliding rotating action caused by the work being set on an angle instead of being radial to the center of the wheels
3. The eccentric spider motion giving an in-and-out sliding action of the pins from the center of the wheel.

[1] Reed-Prentice Company.

Discussion of a paper on Precise Cylindrical Lapping, by Paul M. Mueller, presented at a meeting of the A.S.M.E. Machine Shop Practice Division, Mason Laboratory, Yale University, New Haven, Conn., September 10, 1925. Mr. Mueller's paper appeared in the September, 1925, issue of Mechanical Engineering, p. 701.

For production purposes at least two machines are regularly used, one for rough lapping and one for finish lapping. This method is by far the most economical and satisfactory. However, where a small production will not warrant the use of two machines, one machine may be used by being equipped with a pair of roughing wheels complete with flanges and a pair of finishing wheels complete with flanges.

Where two machines are used, that is, one for roughing and one for finishing, a spider full of pins is placed in the rough-lapping machine, and when inspected satisfactorily, the spider with the pins is passed directly to the finishing machine. This condition permits the pins lapped to exactly the same diameter to be passed on to a finishing machine without removing the pins or work from the spider. In the case of the small production where only one machine is used, it is of course necessary to first rough-lap a quantity of work and then set the machine up for finish lapping. To obtain the maximum results on a high-production basis a number of work holders are used, thereby permitting extra holders to be loaded while the others are in use on machines.

Production of Piston Pins

Piston pins are made in various ways, a typical method of which might be outlined as follows:

Material: Cold-drawn steel, S.A.E. 1020, 2315, 3120; stock is purchased 0.015 in. over finished pin size.

	Stock removed, in.	Stock left for next operation, in.
First Operation: Machine hole and ends complete in automatic screw machine	0.0000	0.0150
Second Operation: Heat-treat. Fill central hole with asbestos and carbonize 1/32 in. to 1/16 in. deep (average 1/32 in.). Harden to scleroscope hardness 80 to 85	0.0000	0.0150
Third Operation: Rough-grind in centerless grinder with three cuts:		
First cut, stock removed 0.0050 in.		
Second cut, stock removed 0.0050 in.		
Third cut, stock removed 0.0025 in.	0.0125	0.0025
Fourth Operation: Finish-grind in centerless grinder with two cuts:		
First cut, stock removed 0.0015 in.		
Second cut, stock removed 0.0005 in.	0.0020	0.0005
Fifth Operation: Rough-lap in Mirra cylindrical lapping machine	0.0004	0.0001
Sixth Operation: Finish- (polish) lap in Mirra cylindrical lapping machine	0.0001	0.0000

Tolerances

The limits usually allowed on the finish-lapped piece are as follows:

Roundness	within 0.0001 in.
Taper	within 0.0002 in.
Diameter	from 0.0002 in. to 0.0005 in.

It may be immediately stated that the out-of-roundness of the work produced from the Mirra machine is negligible, as this is practically zero in every instance. The diameter and the taper can easily be kept within 0.0002 in. without any unnecessary effort on the part of the operator. When necessary, the diameter can be kept within 0.0001 in. with special care on the part of the operator.

It is our standard practice to allow from 0.0004 in. to 0.0005 in. stock to be removed from the diameter in the rough lapping, and not more than 0.0001 in. in the finish lapping. This will be noted from the previous itemized operation.

Prior to the lapping operation the pieces are finish-ground with a fairly good finish, and we usually leave the finish-grinding diameter

oversize by the amount of stock removed in rough lapping, plus the tolerance obtainable in grinding. For example: If a piece of work were to be finish-lapped to 1.0000 in. minus 0.0000 in. plus 0.0002 in., the analysis of the size left for rough lapping would be made as follows:

Maximum diameter after finish lapping	1.0002 in.
Amount of stock to be removed, rough lapping	0.0004 in.
Minimum grinding diameter	1.0006 in.

Therefore, with the finish-grinding allowance of 0.0002 in., the finish-grinding sizes range from 1.0006 in. to 1.0008 in., thus necessitating the removal of 0.0004 in. to 0.0006 in. in the lapping.

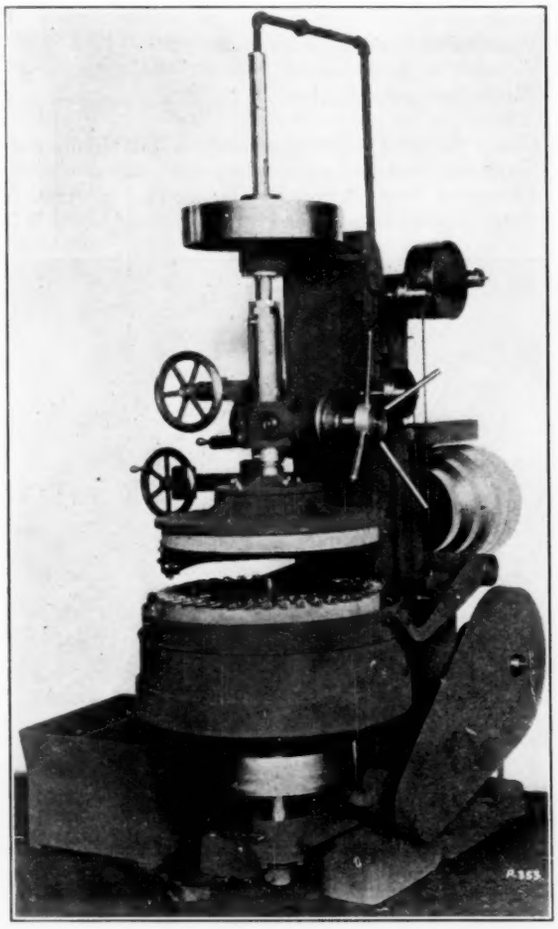

FIG. 1 CYLINDRICAL LAPPING MACHINE, RIGHT SIDE, WITH FILLED WORK SPIDER INSERTED

By removing this the piece after being rough-lapped would be to the high limit of the finish lap; therefore the stock being removed from 0.00005 in. to 0.0001 in. in the finish lap would be within the finish tolerances.

CONSERVATIVE RATE OF COMMERCIAL LAPPING

Practically, the lapping time required in production is about the same for the roughing and finishing operations. To illustrate the rapidity in which the Mirra method produces lapped piston pins, Table 1 is presented, which gives a conservative production per hour per operation (either rough or finish) per machine for different diameters and lengths of pins. This of course would also apply to any other cylindrical work of a similar nature.

TABLE 1 CONSERVATIVE PRODUCTION PER HOUR

Diam. of work, in.	Maximum length of work, inches				
	1	2	3	4	5
3/8	1340	1226	1095	980	862
1/2	1155	1050	950	847	730
5/8	1010	920	823	730	643
3/4	890	818	730	657	569
7/8	..	730	657	585	512
1	..	672	598	540	467
1 1/8	..	614	556	496	423
1 1/4	..	569	512	453	395
1 3/8	..	526	467	424	365
1 1/2	..	496	438	394	351
1 3/4	..	...	395	336	307
2	..	...	351	307	278

When using two machines, one for rough lapping and the other for finish lapping, the average output of finished pins per hour would be in accordance with the table, and in order to reduce the idle time of the machines to a minimum it is customary to have from six to eight work spiders, one operator for each machine, and a helper to load the work on the spiders. The method of inspecting the finished work differs in the various plants. However, those producing the most accurate work have an inspector to gage the pins loaded on the spiders after the same have been rough-lapped, and previous to finish lapping. Where the quantity of production does not warrant this, the operator of the rough-lapping machine usually inspects his own pins before passing them on to the finish-lapping machine.

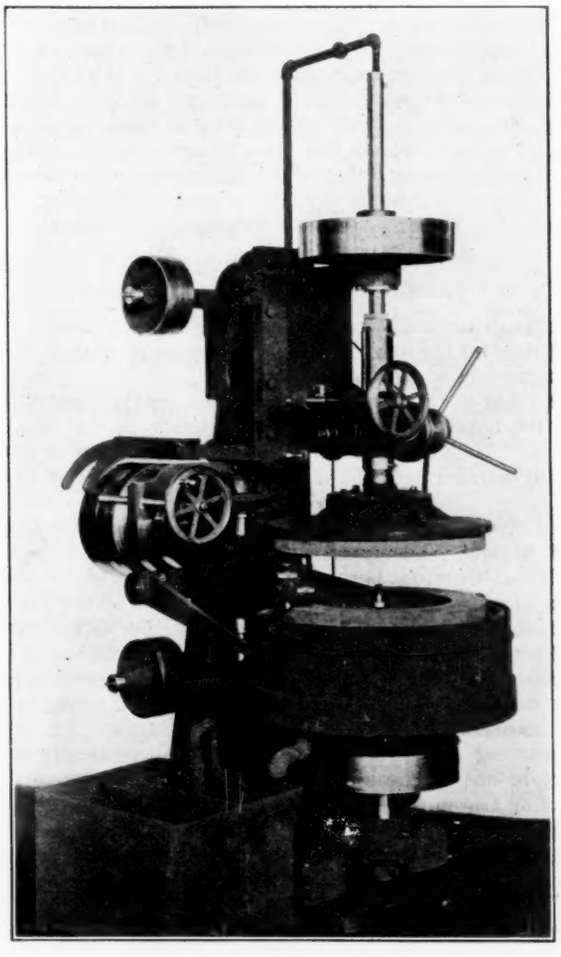

FIG. 2 CYLINDRICAL LAPPING MACHINE, LEFT SIDE, WITH WORK SPIDER REMOVED

WORK HOLDERS

The work holders vary with the different types of work lapped. However, a type commonly used for the lapping of medium sizes of automobile-piston pins is shown in Fig. 1 and in general detail in Fig. 3. This type is commonly known as the "work spider." The piston pin is loosely slipped over the non-radial spider arm after the collars on the arms have been removed, as shown by the two arms at the extreme right of the photograph. These spider arms are all heat-treated steel to provide for wear, and have a shoulder adjacent to the central portion of the spider to take the thrust of the pin. There is usually about 1/8 in. play between the hole in the piston pins and the arms of the spider, and the quick-acting removable collars on the spider arms allow a slight end play of the work on the arms.

To load, the spider is usually placed on a support on a bench or table conveniently placed adjacent to the machine. The spider is

arranged without the quick-acting removable collars, thereby permitting the work to be slipped over the projecting arms quickly. As each piece of work is slipped on to the arms, the quick-acting collars are set in place through a bayonet-lock arrangement at the outer end of the arms. For placing the loaded spider into the machine the upper wheel is placed in the position shown by Fig. 1. The spider is located on a stationary eccentric pin protruding from the central opening of the lower wheel. This eccentric pin has a running fit in the hole of the spider which permits the spider to freely rotate about the pin center, thereby giving the work on the spider an eccentric movement over the cutting surface on the wheels. In order that the projecting arms of the spider will not rest on the lower portion of the holes in the piston pins or the work being lapped, a shoulder collar is mounted on the eccentric pin, and is so positioned that the entire work spider is suspended on the collar. As the arms of the spider are smaller in diameter than the holes in the work, the clearance between the spider arms and the holes is thus kept evenly distributed between the upper and lower portions of the holes. The work spiders can often be arranged to accommodate several sizes of pins, and they offer a simple and inexpensive arrangement. For work not having holes through the center, a circular-plate spider is furnished with openings into which the work is placed.

METHOD OF TRUING LAPPING WHEELS

For rough lapping, a medium-grain, soft grade of emery wheel is used, while for the finish lapping the very finest possible grain and softest grade of wheel is used.

The lower wheel is rigidly mounted to the lower-wheel spindle, while the upper wheel has a floating action on the upper-wheel spindle. This floating action permits the upper wheel to find itself perfectly parallel with the work and cutting surface of the lower wheel.

When truing either wheel, it is of course necessary that both wheels be rigid. The upper-wheel clamping flange mounted on the spindle has therefore been arranged with three square-head setscrews which, when screwed downward, remove all the floating action in the upper wheel. Therefore, to true the upper wheel, this wheel is raised and locked so that the cutting surface is on a plane just above the upper diamond mounted in an arm on the left side of the machine. The position of the wheels for truing is clearly shown in Fig. 2.

The truing arm is arranged with two independently operated diamonds, one for the upper wheel and one for the lower. With the truing arm in the position shown in Fig. 2, the upper diamond is adjusted upward by a knurled collar until it just comes in contact with the upper wheel. The diamond is then fed back and forth across the wheel by the use of the truing-arm handwheel located adjacent to the arm.

The lower wheel is trued in an identical manner, and in order to keep the wear of the wheels at a minimum, as light a cut as possible is removed by the diamond. Under average conditions it is only necessary to true the wheels about every 3000 to 5000 pins. It is of advantage occasionally to dress the wheels, thus eliminating the necessity of truing. This is done by simply passing a dresser back and forth over the cutting surface by hand. As the wheels are thoroughly moistened by the constant flow of compound, the diamond produces a wet chip, and thus prevents emery dust from flying on to the machine. After truing, the wheels are washed and thoroughly cleaned from all loose emery, thus permitting all grains to be cleanly open and preventing any of the emery from getting on the work.

WATER COMPOUND

It has been found most satisfactory to date to use a compound of water and oakite when lapping, the ratio being one pound of oakite to ten gallons of water. This solution keeps the wheels and work clean at all times, and also prevents rusting. It may be said that this process of lapping is absolutely clean from emery, which eliminates any possibility of emery getting into the bearings into which the finished lapped parts are used.

LAPPING EXPERIMENTS—THEORY

Lapping is an art. Through the machine described we are endeavoring to place it on a scientific basis. To do this it is first necessary to determine the effect of each varying factor in a lapping operation, to study each separately, and then, after finding the effect of each, make a separate analysis for the effect of each on the whole. In making a careful study, the varying factors so far presented are as follows:

1 Amount of stock removed
2 Work
3 Eccentricity of work spider
4 Speed of wheels
5 Dressling of wheel cutting surface
6 Truing of wheel cutting surface
7 Cutting compound
8 Pressure of wheels on work
9 Number of pieces on work spider
10 Number of pieces lapped
11 Grade and grain of wheel
12 Time.

To obtain the most important variables and eliminate the constants, each may be taken separately in the order previously listed.

1 *Amount of Stock Removed.* The amount of stock removed in the rough lapping is controlled by the limits obtainable from the

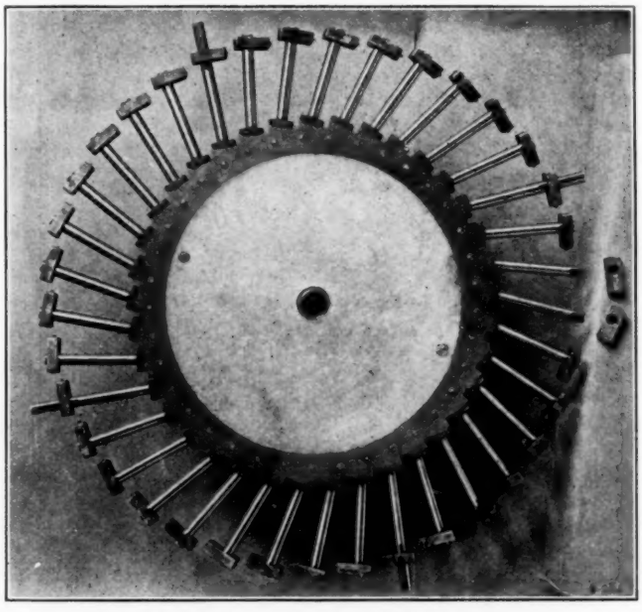

FIG. 3 TYPE OF WORK HOLDER COMMONLY USED

finish centerless-grinder operation and the tolerance allowed on rough lapping. From the practice previously referred to, the variation in stock removed in the rough lapping is from 0.0004 in. to 0.0006 in. As it has seemed most practical to perform a test on a manufacturing basis, the variable of 0.0002 has been disregarded, so that the amount of stock removed may be considered as a constant.

2 *Work.* Due to the large number of one type of piston pins being manufactured when the tests and experiments were made, we are able to proceed to make the entire test on one type of pin, thereby keeping all dimensions, material, and hardness of work constant.

3 *Eccentricity of Spider.* This condition can be varied, and it was therefore necessary for us to find the effect on the work caused by the changing of the eccentricity of the spider.

4 *Speed of Wheels.* To determine the exact action of the grade and grain of the wheel on the work, it is necessary to find out the effect on the work caused by the varying of the speed of the wheels.

5 *Dressing of Wheel Cutting Surface.* For the present our tests are based on one dressing of the wheels per experiment, although at a later date it may probably seem to advantage to find the effect of the rate of production and the finish of the work caused by the dressing of the wheels.

6 *Truing of Wheel Cutting Surface.* Also, in the case of truing, for the present it seems advantageous to true the wheels only once per experiment.

utting Compound. For experimenting, the volume of cutting ound was kept constant, with a flow of 10 gal. per min., the redients of the compound being in the ratio of 1 lb. of oakite to 10 gal. of water.

8 *Pressure of Wheels on Work.* It is self-evident that varying pressures of wheels on the work would affect both the rate of production and the finish. It is therefore necessary to determine this by considering pressure as a variable.

9 *Number of Pieces on the Work Spider.* So that the pressure of the wheels per square inch of work surface is kept constant, the same number of pieces on the work spider is necessary for all experiments.

10 *Number of Pieces Lapped.* To obtain accurate results it is absolutely essential that the total number of pieces lapped per experiment be kept constant. It is therefore decided to make each experiment consist of 1500 pieces.

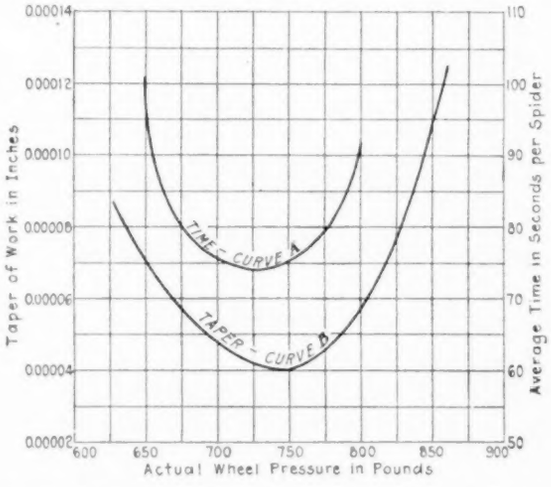

Fig. 4 Relation of Wheel Pressure to Time and Taper

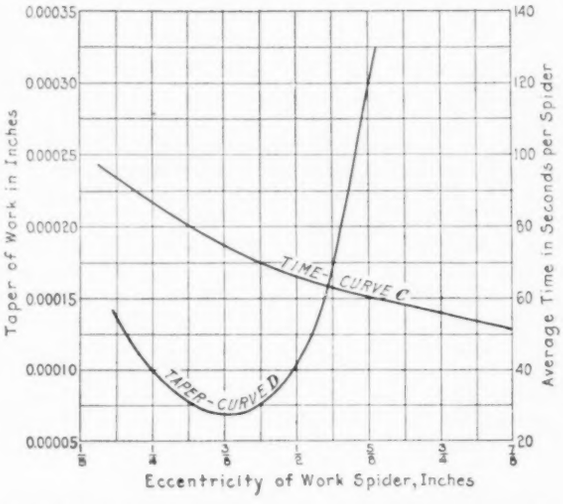

Fig. 5 Relation of Eccentricity of Spider to Time and Taper

11 *Grade and Grain of Wheel.* The cutting action furnished by the wheel depends considerably on its grade and grain. It is therefore obvious that different wheels will have to be used.

12 *Time.* Time may be considered a rate of production. All other conditions in this test are affected by the time element, and it is believed that all results obtained will be most satisfactory when based relative to time. The time element in all conditions is therefore considered as a variable.

Summary. From the previous paragraphs we may summarize the constant and variable factors as follows:

Constant:

1 Amount of stock removed
2 Work
5 Dressing of wheel cutting surface
6 Truing of wheel cutting surface
7 Cutting compound
9 Number of pieces on work spider
10 Number of pieces lapped

Variable:

3 Eccentricity of work spider
4 Speed of wheels
8 Pressure of wheels on work
11 Grade and grain of wheel
12 Time.

Method Used and Result of Experiments

Wheel Pressure on Work. For determining the effect of wheel pressure on the work, all conditions are kept constant with the exception of pressure and time. To obtain the pressure of the wheel on the work, the upper wheel was arranged with a moment arm in place of the pilot handwheel on the right side of the machine. Connecting the outer end of this arm to the floor was a spring-balance arrangement, thereby giving a means of applying variable pressures of the upper wheel on the work. To obtain an exact direct wheel pressure from the spring-balance arrangement, a pressure scale was placed under the upper wheel so that the exact pressure of this wheel was known by each spring-balance rating. This procedure took into consideration the mechanical friction encountered in the machine, and the weight of the wheel was kept separately so that as the cutting surface was trued from time to time, the reduction in weight of the wheel was known. The results of the effect of pressure are shown by the curves of Fig. 4. Curve *A* in this figure shows that the time consumed varies with the wheel

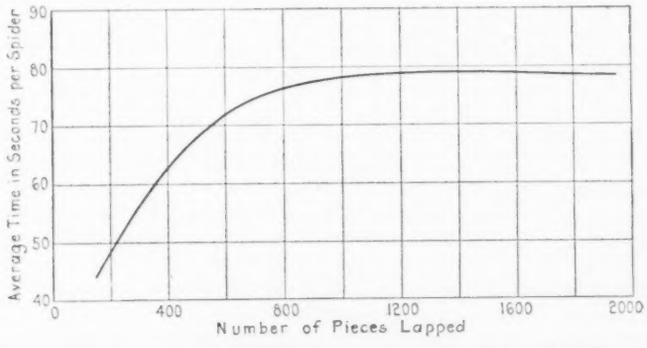

Fig. 6 Relation of Average Time per Spider to Number of Pieces Lapped

pressure, and that the time decreases with the increase of pressure up to a wheel pressure of about 725 lb., and from there on increases in approximately the same manner.

From curve *B*, it is very interesting to note that the pressure has approximately the same effect on the tapering of the work as it has on time.

Both curves have approximately the same shape, therefore showing that it is very important to have the correct pressure of the upper wheel on the work to obtain the most satisfactory results.

Eccentricity of Work Spider. To determine the effect of varying the eccentricity of the work spider, all elements with the exception of the eccentricity and time were kept constant, and the effect of the eccentricity was determined by making several experiments with the eccentric pin located in different positions. The results of this test are shown by the curves of Fig. 5. From curve *C* it will be noted that time decreases with the increase of the eccentric movement of the work spider, showing that the more eccentricity used within certain limits, the faster the stock is lapped from the pin. Curve *D* illustrates the tapering effect on the work with the variation of eccentricity. With the smaller amounts of eccentricity the taper increases, and with an increase of eccentricity the amount of taper decreases. However, from $^3/_8$ in. and higher eccentricity, the taper increases at an extremely rapid rate.

In comparing curves *C* and *D*, it will be appreciated that the taper, curve *D*, is the controlling factor, as the accuracy or quality of the parts produced is more important than the rate of production. Therefore, the most satisfactory amount of eccentricity under the average conditions would be approximately $^3/_8$ in.

Speed of Wheels. From the tests made to date in order to determine the effect of varying speed of the wheels, it is impossible to give a satisfactory set of curves. However, it will be stated that the best results have been obtained by a mean wheel speed for the upper wheel averaging 180 ft. per min. and the lower wheel averaging 220 ft. per min. This would give a rolling effect on the work averaging approximately 300 ft. per min.

Grade and Grain of Wheel. Several wheels have been used, and up to the present the best wheel for the rough lapping has been found to be a Norton 80K alundum vitrified, and for the finishing, a Norton XFI crystolon elastic.

PRODUCTIVE CAPACITY OF LAPPING MACHINE AS SHOWN BY TESTS

In a previous paragraph we have given a conservative rate of production per hour per machine for commercial lapping on a productive basis. Fig. 6 shows the relation of average lapping time to the number of pieces lapped. This curve was made from data which included only up to 2000 pins, but it is very interesting to note that the highest time required per work spider of forty 1-in. pins approximately 3 in. long did not exceed 78 sec. From this it will be readily appreciated that the tabulated figures previously mentioned for productive handling are conservative.

CONCLUSION

In conclusion, the practical productive value to both manufacturer and user of lapped commodities may be conceived from the following items:

1 A greater rate of production is obtained than by any other cylindrical lapping machine now on the market.

2 The Mirra cylindrical lapping machine produces extremely accurate work for commercial use, which has reduced the cost of assembling automobile lapped parts materially.

3 The lapping wheels are trued by the use of a diamond, and independently of each other. This is the most efficient, simplest, and quickest way of truing laps for commercial use. The cost of replacement of the wheels used is considerably less than that of metal laps and emery.

4 The surface produced is exceptionally high-polished.

5 Pins are absolutely clean—free from all emery—when taken from the machine, thus permitting the parts lapped to be assembled without the possibility of emery causing later damage when the parts are in operation.

6 The method of lapping removes stock at a rapid rate, reducing the cost of the finish-grinding process required previous to the lapping operation.

7 Practical production proves that automobile-piston pins are lapped on this machine at a small additional cost of practically one-half cent each for average sizes of pins.

8 The machine does not require a high-priced skilled mechanic to operate it. An ordinary machine operator of reasonable intelligence can easily become highly efficient if careful and attentive.

9 Only the simplest tooling is required. In many instances one work spider will handle from three to four different sizes of work.

Problems Encountered in Machining Brass Rod

BY JOHN L. CHRISTIE,[1] BRIDGEPORT, CONN.

THE present discussion of Mr. Burlingame's paper is submitted in an attempt to bring about a closer understanding between the manufacturer and the user of brass rod. A knowledge on the part of each one of what the other is trying to accomplish and of the difficulties and limitations he meets, is essential to mutual satisfaction.

Both the manufacturer and user are fortunate in that brass rod has been standardized as to sizes, composition, and general method of manufacture. The last two, of course, control the properties of the finished rod. Standardization has progressed further in the case of rods than in other forms of brass. The standardization permits the manufacture of a standard article in large quantities, and the prompt shipment from stock.

Occasionally, special requirements on the part of the user demand a special rod. This entails either a composition different from the standard, a different processing in manufacture, or both. This is of interest in connection with the first paragraph in the paper in which the author, referring to operating on soft metals, states that there is as yet no standardized practice. We have known of instances where two different screw-machine-operating concerns, making the same part for the same customer, required different rods because of their different set-ups. One was able to use the standard rod shipped from stock, while the other demanded a rod of special properties.

Referring now to the section of the paper entitled The Kind of Metal to be Used, the term "hard" has a different meaning to the manufacturer and to the user. The same, of course, applies to the term "soft." To the user the term "hard" applied to brass rod means that it is difficult to cut; the term "soft" means that it is easy to cut. To the manufacturer the term "hard" means high tensile strength, stiffness, high Brinell, scleroscope, and Rockwell hardness numbers, and does not necessarily mean that the rod is difficult to cut. The manufacturer, for the cutting qualities, uses the words "free-cutting" and "not free-cutting."

In steel and in iron, metal that has high strength, high Brinell, etc. is in general not free-cutting, and metal that has low strength and low Brinell is free-cutting. In brass the same relation does not necessarily hold, and the most important factor in determining free-cutting properties is the lead content. This should be maintained at about 3 per cent; if it runs materially above this, trouble will be experienced in manufacture and in the rod itself due to lack of strength; if it runs below about 3 per cent, the maximum free-cutting properties will not be attained. The difference in lead content explains why, as Mr. Burlingame states, brass rod made abroad does not cut so readily as similar stock made in this country. It also explains why tubing as a rule is "harder" (in the meaning of the user) than brass rod. When the lead content of brass tubing is higher than about 1 per cent, considerable difficulty in manufacture is encountered. The hardness (strength, stiffness, etc.) of brass is controlled largely by the amount that it is drawn either from the extruded size or after the last anneal. This, however, has comparatively little to do with the free-cutting properties of the rod. The rod should be drawn stiff enough so that the cutting tools will not push it out of shape. And the best results, of course, are obtained by accurate control of the composition and processing of the rod.

An interesting example of the difference in the meaning to the manufacturer and to the user of brass rod of the word "hard" occurred a few years ago. A customer of the Bridgeport Brass Company and a large user of brass rod complained that he was having trouble on one particular size of rod. He stated that the rod was hard, was dulling tools and breaking drills, and was generally unsatisfactory. An investigation showed that a drilling operation was being performed at the same time that a wide, heavy forming cut was being taken from the side. The forming cut was so heavy that the piece was actually being bent out of line with the remainder of the rod. This caused the axis of the end of the piece to move in a circle, thus snapping the drills, dulling the tools, and breaking the rod. It was found that by giving the customer a rod which had been drawn stiffer—in other words, which was harder in the mind of the manufacturer—the trouble was eliminated and the customer well pleased. In this case a rod that was thought to be too hard was really not hard enough.

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[1] Metallurgist, Bridgeport Brass Company.

Discussion of a paper on High-Speed Cutting of Brass and Other Soft Metals in Machine Tools, by Luther D. Burlingame, presented at a meeting of the A.S.M.E. Machine Shop Practice Division in Mason Laboratory, Yale University, New Haven, Conn., September 10, 1925. Mr. Burlingame's paper appeared in the September, 1925, issue of MECHANICAL ENGINEERING, p. 705.

The Tension Ratio and Transmissive Power of Belts

By C. A NORMAN,[1] COLUMBUS, OHIO

An investigation of the increase of transmissive power with slip was conducted on an apparatus patterned after that of Friedrich at The Ohio State University on rubber, leather, and fabric belts. The results of the investigation are given in the form of curves, and the conclusions drawn from the tests are noted.

IN 1885 Wilfred Lewis[2] of Wm. Sellers & Company published some tests on the transmissive power of leather belts which still remain fundamental and noteworthy and have served as the starting point for remarkable analyses undertaken by Carl G. Barth[3] and others.

The tests were carried out by means of running belts, and the initial tension as well as the effective pull, the tension ratio, and the slip were determined and recorded. In Fig. 1 is given a set of curves plotted from Lewis' findings for a leather belt in good pliable condition. These curves show the dependence of the tension ratio on the velocity of slip. They indicate that with increasing slip the tension ratio increases, at least within certain limits. In other words, the greater the slip, the greater is the percentage of the maximum tension converted into effective pull.

It is to be remarked that all of these results were obtained at a belt speed of about 800 ft. per min. and with the same pulley of 20 in. diameter. As far as Lewis' tests are concerned, there is therefore no reason to ascribe the increased tension ratio to any other influence than increased slip, and possibly to increased power transmitted.

In 1907 and 1912 Professor Kammerer in Charlottenburg published certain tests undertaken with pulleys varying in diameter from 600 mm. (23.5 in.) to 2500 mm. (98.5 in.) and with speeds running up to 12,000 ft. per min.[4] From these tests the conclusion was drawn that for a variety of reasons the coefficient of friction apparently increases with the belt speed.

In order to eliminate the influence of belt speed and belt stretch entirely, A. Friedrich[5] undertook certain tests with a stationary belt hung over a slowly revolving pulley.

The pulley, of 500 mm. (19.7 in.) diameter, was made to revolve at speeds such that the relative velocity between the pulley rim and the belt corresponded to ordinary slip velocities. Some of Friedrich's average results are plotted in Fig. 1. It will be seen that the tension ratio varies with the slip in very much the same way and between the same values as Lewis found for pulleys of the same material. There is therefore little reason to assume anything else than that the slip is at least the main factor tending to make the transmissive power of a leather belt increase with increased speed.

Tests at the Ohio State University

The Engineering Experiment Station of The Ohio State University installed in the mechanical engineering laboratory of the university a belt-testing machine of the type used by Friedrich. The machine carries a test pulley on which a stationary belt is suspended. The pulley is of cast iron, either crowned or flat, and has a diameter of 18 in. A weight is adjusted to correspond to the slack-side tension of the belt. By means of a spring balance and, if necessary, an additional deadweight, the tension on the pulling side is measured. The machine is driven by means of two gear sets and a chain transmission from the Reeves speed variator employed. By means of this device the rim speed of the pulley can be varied from little more than 1 ft. up to more than 15 ft. per min.

On this machine a number of senior students conducted belt tests under the direction of the author during a period of about a year and a half. The present paper is based on these tests.

Method of Conducting and Evaluating Tests

Deadweights were placed so as to produce a desired slack-side tension in the belt. The machine was then run at speeds which were increased by steps. The tight-side tensions for each speed were read on the spring balance. In this way a set of figures were obtained such as shown by an example in Table 1.

TABLE 1 TEST OF 4-PLY RUBBER BELT A, 4 INCHES WIDE

(T_2 per inch of width equal to 10 lb.)

Slip, ft. per min.	T_1, lb.	T_2, lb.	$T_1 - T_2$, lb.	$\frac{T_1 - T_2}{T_1}$	$\frac{T_1}{T_2}$
1.62	125	40	85	0.68	3.125
1.98	127	40	87	0.684	3.175
3.14	130	40	90	0.69	3.25
4.5	133	40	93	0.70	3.32
6.4	136	40	96	0.705	3.40
8.87	141	40	101	0.716	3.52
12.5	144	40	104	0.723	3.60

A number of runs of this character were plotted on one curve sheet as shown by an example in Fig. 2. T_2 is the slack-side tension. T_1 is the tight-side tension. From these plots curves for T_1/T_2 and $(T_1 - T_2)/T_1$ against T_2 were plotted. Finally sets of curves for T_1/T_2 against slip were obtained (Fig. 3), and from these comparative curves showing $(T_1 - T_2)/T_1$ against slip for various values of the effective pull $T_1 - T_2$, and for various materials. Some of these curves are given in Fig. 4.

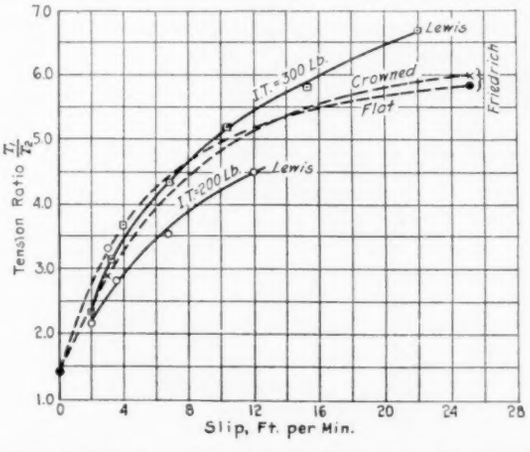

FIG. 1 BELT TESTS BY LEWIS AND BY FRIEDRICH—SINGLE LEATHER BELT, LIGHTLY DRESSED, ON CAST-IRON PULLEYS

[I. T. is initial tension ($T_1 + T_2$, according to Lewis' assumption). T_2 in Friedrich's tests varied from 22 lb. to 110 lb. for a 4-in. (100 mm.) belt. Lewis' belt was 5½ in. wide; his pulley had a diameter of 20 in. Friedrich's pulleys had a diameter of 19.7 in. (500 mm.).]

These are the curves in which the practical man is interested. In practice the belt is proportioned for its service by the assumption of various effective-pull values per inch of width of belt. Usually these values for single belts fall within the limits given in the curve. A figure as low as 25 lb. per inch of width would correspond roughly to the recommendations of Taylor; one of 50 lb. per inch width is about the highest value used in practice to save first cost. In Fig. 4, $(T_1 - T_2)/T_1$ indicates what fraction of the maximum belt tension is turned into effective pull, i.e., is doing useful work, for values of $T_1 - T_2 = 35$ lb. per in. width, and for various materials.

Discussion of Results

The curves in Fig. 4 apply to new belts. The belts, as will be noted, are one mineral- ("special") tanned and one oak-tanned leather belt, both single; two 4-ply rubber belts, A and B, of different makes; one balata belt; and one impregnated fabric belt. It is to be observed, however, that it was not found possible with

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[1] Professor of Machine Design, The Ohio State University. Mem. A.S.M.E.

[2] Trans. A.S.M.E., vol. 7 (1886), p. 549.

[3] Trans. A.S.M.E., vol. 31 (1909), p. 29.

[4] *Zeitschrift des Vereines deutscher Ingenieure*, 1907, p. 1085, and 1912, p. 206.

[5] *Zeitschrift des Vereines deutscher Ingenieure*, 1915, pp. 537, 580 and 608.

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the aid of the T_2 values used to establish curves for $(T_1 - T_2) = 25$ lb. per inch of width for a balata belt, and 50 lb. per inch of width for an oak-tanned leather belt. The rubber belts were both of the so-called "friction-surfaced" variety. This term refers to the mode of manufacture and should not be understood to mean that the belts were covered with any special surfacing intended to increase friction.

The special mineral-tanned leather belt in all cases turned the

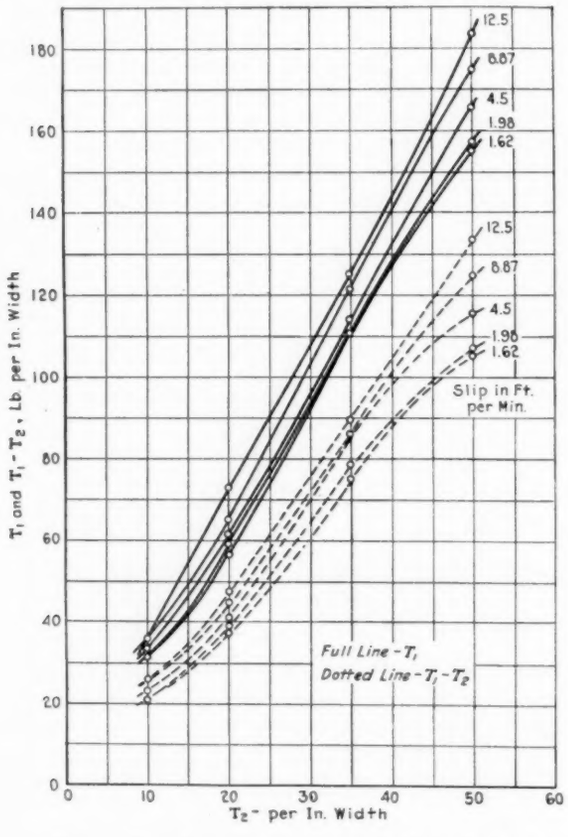

FIG. 2 TEST RESULTS OF 4-PLY, 4-IN. RUBBER BELT A

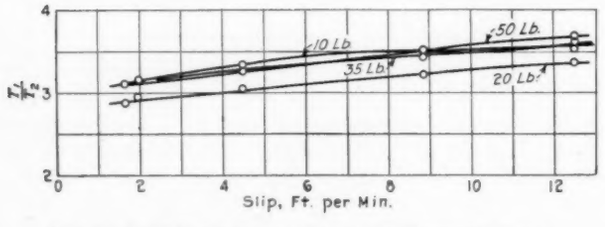

FIG. 3 TEST RESULTS OF 4-PLY, 4-IN. RUBBER BELT A
(For values of T_2 per inch of width as noted on curves.)

greatest portion of the maximum tension into effective pull. It was followed by balata, rubber A, rubber B, impregnated fabric, and new oak-tanned leather. To transmit 50 lb. per inch of width, the last-mentioned would have required higher T_2 values than were used. It should be emphasized at once that this low tractive power is characteristic only of new and possibly likewise of entirely worn-out oak-tanned leather belts. A short period of running increases their tractive power very materially. This was ascertained in a separate test. Values for $(T_1 - T_2)/T_1$ figured from these curves rise to 90 per cent and more, and increase uniformly with the slip. This belt was stated to have run 10 hours on the belt-testing machine of the Graton & Knight Manufacturing Company at Worcester, Mass.

A maximum point seems to occur within the slip values used on the curve for the balata belt at an effective pull of 35 lb. per inch of width and on those for the rubber belt A both at 35 and at 50 lb. per inch of width. This means that for slips beyond the maximum point a higher tight-side tension is needed to transmit the effective pull in question than at this point. All the other belts show the property of transmitting the pull with decreasing tension the more the slip increases, at least within the range of slip values used. Even beyond the maximum, the rubber belt A and the balata belt show, however, a very creditable performance. The rubber belt turns at least 65 per cent of the maximum tension into effective pull, and the balata belt, 85 per cent. In other words, while the pulling power of these belts may not increase uniformly with the slip, it cannot be said that the belts need overtightening to carry any effective pulls in common use.

TESTS ON USED BELTS

Shafts and bearings must be dimensioned so liberally that they can stand the highest belt tension ever likely to be applied. From this point of view the "critical" period, when oak-tanned leather belts are used, is the one when the belts are new (also of course, when they are worn out). It was found that an old leather belt which had been dressed only with belt preservative (tanner's oil) gave a very low value for $(T_1 - T_2)/T_1$. If oak-tanned leather belts are to transmit their full rated power in the new condition, very high tight-side tensions must be used. On the other hand,

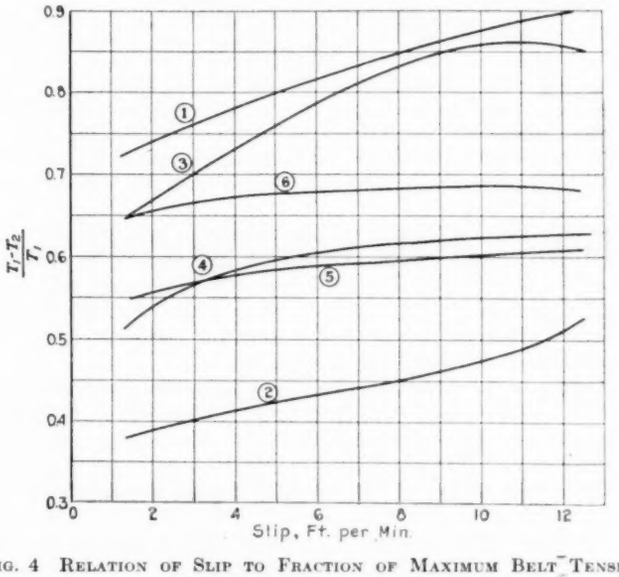

FIG. 4 RELATION OF SLIP TO FRACTION OF MAXIMUM BELT TENSION TURNED INTO EFFECTIVE PULL
(Curve 1, Special-tanned leather, Curve 2, Oak-tanned leather; Curve 3, Balata; Curve 4, Rubber B; Curve 5, Impregnated fabric; Curve 6, Rubber A. For values of $T_1 - T_2 = 35$ lb. per inch of width.)

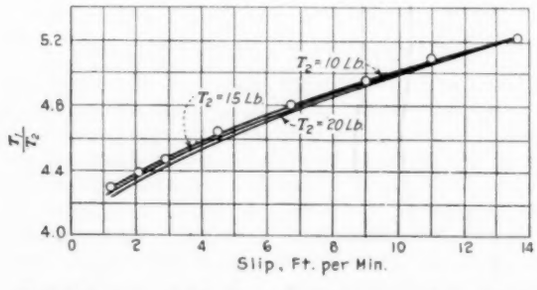

FIG. 5 TEST RESULTS OF 4-IN. RUBBER BELT AFTER TWO MONTHS' USE
(For values of T_2 per inch of width as noted on curves.)

the shafting friction during the long years of service is determined by the degree of tightness needed after the belts have been run in, and here leather belts of all kinds, when clean and pliable, give very favorable conditions.

The question is, how do rubber belts behave in this respect? It would have been desirable to find this out by tests on belts which had run for at least some months in regular commercial service. Unfortunately it proved impossible to obtain for test purposes used belts in good condition from ordinary users. The B. F. Goodrich Company, however, kindly consented to run in a belt in their factory specially for the purpose. The test curves for this

belt are given in Fig. 5. The values $(T_1 - T_2)/T_1$ derived from these curves are throughout the range at least as good as those for rubber belt A in Fig. 4. On the whole it appears as if a rubber belt gave almost its full tension utilization from the very beginning, and maintained it at least for some time. An old and worn-out rubber belt is no better than an old and worn-out leather belt. It gives a tension utilization of about 50 per cent. Attempts to raise this rate by application of castor oil did not give a very material improvement at The Ohio State University.

CONCLUSIONS

The conclusions one would draw from the tests here reported are as follows: The transmissive power of belts on cast-iron pulleys shows in general and within certain limits a tendency to increase with the slip. This tendency is especially marked in the case of certain mineral-tanned leather belts, and of oak-tanned belts which have passed through a running-in period. It occurs, however, also in the case of rubber belts, balata belts, and various impregnated textile belts.

In the case of certain rubber belts and balata belts the increase of transmissive power with slip reaches a maximum beyond which no further increase takes place. The percentage of maximum tension turned into effective pull may, however, remain creditable even beyond this point. In other words, the belts do not need to be overtightened.

The percentage of maximum tension turned into effective pull is greatest for the special mineral-tanned belts investigated; is very high also, especially at some slip, for a leather belt that has been run for a short time; and is high for balata belts. It exceeds 60 and even 70 per cent for some rubber and impregnated fabric belts.[1]

New oak-tanned leather belts, not run in, convert into effective pull a smaller fraction of the maximum tension. Rubber belts, balata belts, certain textile belts and the special mineral-tanned belt give their full service from the very start. A few months of running does not seem to impair the transmissive power of rubber belts.

These conclusions are of course strictly applicable only to the belts tested and to the test method used. The results seem to agree with certain tests on running leather belts, however.

[1] This is true also of a solid woven belt tested separately and not referred to in the text.

New Processes for Making Wrought Iron[1]

WHEN the bessemer process was invented it was generally believed that the days of wrought iron were numbered. Bessemer steel, after the first manufacturing difficulties were overcome, seemed to present so many advantages over the older metal that it did not appear possible for the latter to survive. Garet Garrett in his novel, The Cinder Buggy, dramatically presents the fight between the puddled wrought iron at New Damascus and bessemer steel at Pittsburgh. At first the old ironmaster keeps a batch of steel rails for the sole purpose of showing how brittle and unreliable they are, but gradually, as the difficulties of manufacture of bessemer steel are overcome and as the extension of the railroad system calls for more and more rails and the world generally begins to demand metal in such huge amounts that the puddling furnaces are absolutely unable to supply it, Steel becomes King, and finally the iron works at New Damascus are blown out.

Actually, however, wrought iron not only continues to exist but shows possibilities of expansion. It has certain advantages such as higher resistance at atmospheric corrosion, and while generally the tensile strength of wrought iron is lower than that of steel, a notched piece of wrought iron actually shows higher resistance to alternating stresses than steel.

The greatest obstacle to the increased use of wrought iron was the process of its manufacture. Wrought iron was essentially a hand-made product. Not only that, but its manufacture required in the man producing it a rare combination of great endurance, great physical strength, and skill, a combination which is obviously difficult to satisfy on a large scale with the labor of today. Before wrought iron could become a heavy-tonnage product capable of satisfying a large market, it was necessary to mechanize its production.

THE PUDDLING PROCESS

The ordinary double puddling furnace is of simple construction, consisting of a fire chamber, a working hearth, and a flue. The bottom of the hearth is composed of pure oxide of iron resting upon a cast-iron air-cooled bottom. The sides of the hearth are formed of iron ore, technically known as "fix" or "fettling."

The process itself is quite simple. After the pig iron is charged the puddler endeavors to fuse the whole charge at as nearly at one time and at as low a temperature as possible. This is accomplished by moving the pigs about with a paddle or "rabble," thereby exposing fresh surface to the flame and to the dissolving influence of the cinder bath. The cinder produced during the welding oxidizes and absorbs a large portion of the silicon and manganese. As the temperature increases, rapid decarbonization takes place, giving off a large volume of carbon monoxide which causes the bath to swell ("high boil"). Vigorous agitation of the bath is vitally important throughout the process to produce uniform conditions in all parts and prevent any portion continuing to rest upon the relatively cool bottom.

During the "high boil" individual grains of iron move freely in the surrounding cinder. When the boiling subsides the grains of iron, each enveloped in cinder, form clusters, from which the excess cinder drains off and settles on the bottom. The iron at the bottom of the furnace is clearer than that above. This necessitates turning over the spongy mass, as a result of which it is parted into individual balls and then drawn and taken to the squeezer.

Skilful firing is of the first importance; next to which comes a suitable cinder.

MECHANICAL SYSTEMS OF PUDDLING

To puddle iron successfully by mechanical means it is necessary to approach as nearly as possible the conditions in the hand furnace—in other words, it means being able to mix iron and cinder intimately, to expose every part of the sponge to the heat, and to have full control of cinder and flame conditions. Within the last few years several designs have been tried out in which it is claimed that this problem has been more or less successfully solved.

At the Reading Iron Works, Reading, Pa., the Roe furnace is in operation. It was designed by the general superintendent of the works, James P. Roe, and is rectangular in shape, being 12 ft. wide and 24 in. long. It is so arranged that it can oscillate through an angle up to 120 deg.

The furnace is operated in the following manner: The working bottom, which is formed of pure oxide of iron, is obtained from a small tilting open-hearth furnace in which the oxide is melted. It is then poured into a cast-iron ladle and charged into the puddling machine through a hole in the side near the rail. It flows uniformly over the bottom where it rapidly congeals, as its temperature of fusion is high. Following this the puddling cinder melted in the same type of furnace is charged in the same manner and flowed over the bottom and over the door joint, where it congeals and forms a liquid-tight joint. Immediately after this, molten iron from a mixer is charged. Next, the oxidizing agent, roll scale, is charged by means of a long spoon which distributes the scale uniformly through the whole width of the furnace.

Between spoonfuls the machine oscillates rapidly about 45 deg. each side of the horizontal. During this period air and gas are shut off, producing an oxidizing atmosphere in the furnace, and the whole of the silicon and manganese are oxidized. Gas and air are then admitted, and, as the temperature increases the reactions become

[1] The information contained in this article has been taken from papers presented at the semi-annual meeting of the American Iron and Steel Institute, New York City, October 23, 1925.

apparent and increase in intensity until the high boil is attained, which is the period of the most rapid decarburization; during the whole of this period the machine is moved rapidly, producing violent agitation of the whole bath, with intermissions between each successive five or seven oscillations.

As evidence of the "drop" appears, that is when most of the carbon has been eliminated, the motion is changed to an extremely slow one, and at a somewhat smaller angle, the object now being to prevent the plastic and partially refined mass from going together, as, should it do so, the center of the mass would not be completely refined. Keeping the iron sponge open at this period is a most vital feature, and one which the particular form of bottom is specifically intended to attain.

The whole period of making a heat averages 60 min. It is said that the Reading works has averaged 1000 tons per furnace per month, equivalent to the product of ten ordinary double puddling furnaces, i.e., the productive effort of a skilled puddler is increased twenty-fold.

The rather complicated and inefficient handling of the product of the puddling furnace is also eliminated in the new process, where the ball is removed as a whole and squeezed in a hydraulic squeezer of a special kind. The so-called muck-bar stage is entirely eliminated and the bloom is squeezed to sizes suitable for rolling in a blooming mill and cut to weight in the finishing mill, the blooms taking the place of piles made up of muck bars. From a metallurgical standpoint this is considered to be a better procedure, as it largely eliminates laminations such as occur in wrought iron piled from small units.

Another process for making wrought iron has been patented by W. C. Ely, of Terre Haute, Ind. (these patents are now owned by the American Chain Co.). In this process a furnace is employed which is so arranged that it can be both rotated and oscillated. Fuel oil is used as a fuel, although pulverized coal has been successfully tried out and ordinary coal can be used in certain ways.

In the course of the operations the furnace lining is first heated to a temperature of 2400 deg. fahr., after which a quantity of iron turnings and ferric oxide is introduced in small pieces into the furnace chamber. The furnace is then rotated until the "fix" softens and finally flows freely, ultimately adhering in a solid coating to the magnesite lining of the furnace. A mixture of brown and red hematite ore is used to seal the edges of the lining around the ports where they are exposed. This is claimed to produce a good wear-resisting bottom.

After the lining of the furnace is prepared a quantity of rolled scale and cinder is shoveled in, and after these are partially melted or fused, the furnace is rotated into a proper position and a charge of molten pig iron poured in. As soon as this is done the door is closed and the furnace rotated enough to cause the slag, which now is fluid, to flow to the door sill and jambs and seal the furnace door tightly. The temperature of the furnace is maintained with a reduction in the air supply in order to bring on a boil. During this period the furnace is oscillated through an arc of about 60 deg. and rolled scale is added. As the boiling period recedes, the metal commences to "come to nature," with a lowering of the temperature of the charge, the furnace during this period being oscillated constantly in order to break up the slag film and expose the granules of the metal to the decarbonizing action of the slag and flame. When the metal has fully "come to nature," the furnace is rotated to form the mass into a ball, and at the same time the furnace temperature is maintained at a melting heat so that the particles of iron are homogeneously welded together and the slag maintained fluid. It is very important that the slag be of such a character that, while viscous enough to stick to the iron, it will not be so basic as to require extremely high heating for producing welding in subsequent operations.

It may be mentioned in this connection, though it has not been described before the Iron and Steel Institute, that there is a third process of essentially the same character for making wrought iron, namely, the process developed at the Titan Steel Co., Jersey City, N. J. This was described in an abstract in MECHANICAL ENGINEERING, vol. 44, no. 9, Sept., 1922, p. 604.

The principle of the process, which is the invention of Henry D. Hibbard, lies in producing an intimate mixture of molten iron and oxide of iron by making the charge pour repeatedly over a dam in a thin stream in an oscillating furnace.

The melting stage is carried on in a cupola, from which the molten iron goes into the puddling furnace where the operations of purifying, boiling, and balling follow mechanically the hand method. Essentially, the furnace consists of a cylinder of steel plate about 6 ft. in diameter and 5 ft. 6 in. long with projecting trunnions 18 in. in diameter. The cylinder is lined with magnesite brick to an inside diameter of about 4 ft. The dam, which consists also of magnesite brick, extends up nearly to the center line. The operation is carried on at a temperature of about 2650 deg. fahr. the flame temperature (oil fuel) being 2850 deg.

As soon as the iron begins to form into a ball, the oscillating motion of the furnace is stopped and the furnace is rotated clear over. The ball is carried to a squeezer, where it goes down through a passage of continuously decreasing dimensions and thence it is expelled in rough cylindrical form at the far side, free from surface slag and prepared for the breaking-down rolls. The iron is used largely for pipe and sockets, engine bolts, staybolts, and high-grade merchant bars. Its physical properties are reported to vary in tensile strength from 45,000 to 52,000 lb.; elongation, 15 to 30 per cent. (*The Iron Age*, vol. 110, no. 3, July 20, 1922, pp. 143–145, 7 figs.)

A method developed by James Aston, metallurgist, A. M. Byers Co., Pittsburgh, Pa., is essentially different from those described above. In this case disintegration of the metal is referred to as the keystone of the process. This is brought about in the following manner. Molten iron has a solidification point about 2730 deg. fahr., while the slag fuses at about 2100 deg. fahr. Therefore fused slag is a chilling agent for fused iron, and when molten iron is poured into a bath of slag there is almost instant solidification of the metal and a gas liberation of such force that the metal is blasted into particles. These particles settle and collect at the bottom of the slag bath in a spongy, porous mass entirely similar to a well-worked puddled ball. Because of heat interchange the slag not only remains liquid but becomes hotter and permeates all the interstices of the metallic mass.

With proper proportions of metal and slag, final temperature equilibrium may be reached at 2500 to 2600 deg. fahr. which is a welding heat for iron. The excess slag may be drained off and the mass compacted into a solid bloom in a squeezer or press. It is important that the final temperature equilibrium should be safely below the fusion point of the metal, as otherwise the last portion poured may remain liquid and coalesce as a steely, slagless area in the bloom.

Experiments have been in progress for several years at the works of the A. M. Byers Co. in Pittsburgh, and the existing experimental plant has been operated since February, 1920. About 850 heats have been made, producing blooms ranging in weight from 300 to 1000 lb. The material produced is said to have satisfied the most exacting specification for high-grade wrought iron. Considerable amounts have been rolled direct from the bloom to skelp or plate without repiling, and then made into pipe of entirely normal characteristics.

Hitherto wrought iron has cost more than steel per ton to produce. With the new methods, however, there are possibilities of operating costs in its manufacture closely approaching those of steel manufacture.

Furthermore, as pointed out by H. E. Smith, Engineer of Tests, New York Central Lines, in his paper before the same meeting on The Manufacture and Use of Wrought Iron, to make the largest sizes of present-day finished product it is necessary to have a larger mass of iron than the old-time hand puddler can manipulate. This is doubtless one of the incentives in the present study of methods and apparatus for operating a puddling furnace mechanically or else by some method other than puddling to produce a metal having the same composition, structure, and properties as hand-puddled iron. These new methods and apparatus are aimed at the production of a unit mass of iron many times the size of the old hand-puddled ball. The consumer is very much interested in these developments and hopes to find in them a source of large sections of solid, tough wrought iron free from open seams, and at the same time at a price enough lower than the present standard to enable him to extend the use of iron.

Progress and Prospects in Mechanical Engineering

A Review of Recent Accomplishment in Its Various Branches, Prepared by the Professional Divisions of The American Society of Mechanical Engineers

Foreword

TO IDENTIFY and schedule the numerous branches of mechanical engineering is no mean task. To identify and schedule the outstanding problems in these lines of engineering work is a task of still larger amplitude.

And yet, no service is perhaps more needed. If progress is to be made, problems must be studied, and in order to be studied they must first be recognized.

New knowledge in physics, chemistry, and mathematics is being developed continuously. New economic and social requirements are imposing themselves with each passing year.

The engineer must apply this new knowledge to the conditions of his problems and apply the results in the light of the economic and social requirements of the day.

In no field of engineering is the opportunity for work along such helpful and progressive lines greater than in that of The American Society of Mechanical Engineers.

The administration of the Society recognizes this opportunity and the obligation which attaches thereto and is endeavoring, for the present year, to secure for presentation at the General Meeting some picture of the present condition in the various branches of mechanical engineering, some note of the important lines of progress during the past year, and some indication of the outstanding problems in these various lines of engineering work.

The agency within the Society best fitted to realize these purposes is obviously the Professional Divisions organization, and to it has been committed the task. This organization now represents thirteen subdivisions of the field of mechanical engineering, and the Executive Committees of these Divisions have faithfully endeavored to present, in these reports, information regarding the various subdivisions of our field which should serve, to the membership at large, as enlightment and as stimulus—enlightment as to present conditions and needs, and stimulus to renewed and greater effort in the coming years.

W. F. Durand,
President of the Society

Progress in Machine-Shop Practice

Contributed by the Machine Shop Practice Division

Executive Committee: W. F. Dixon, *Chairman*, W. J. Peets, *Secretary*, J. A. Smith, Carl L. Bausch, James H. Connolly, and E. S. Patch

PROGRESS in improving machine-shop facilities during the past few years has been to a considerable extent a matter of the orderly development of known principles, rather than the discovery of new ones. There are nevertheless exceptions which will be noted. The general tendency has been, quite properly, toward relieving the operator more and more of the burden of tedious hand labor. As new machine tools are substituted for older ones, the operator usually finds that more power and more of his employer's capital have been placed under his control, and that this condition has been accompanied by the capacity for doing more and better work. Who can say that this calls for less ability or responsibility on his part?

Trends in Drives, Controls, and Operation of Machines

To this end, machine-shop machinery is being designed stronger and heavier, and more power is being applied to it. Direct electric-motor drive for machines is coming into greater use, partly as a result of applying more power to the machines and partly because of its facility of control. To a great extent, however, individual-motor drive is popular in spite of more costly installation because it makes possible a cleaner and lighter shop, eliminates overhead works, and permits the placing of machinery to greater advantage. Motor drive is being further developed into unit drive. Several motors are often applied to one machine as this eliminates complicated gear trains and in some cases helps toward more economical construction. Sometimes the base of the machine encloses the motor.

Lubrication is receiving more and more consideration. Pressure and splash feed to all bearings and gears, with filters on the return, are becoming common. The necessity for improved lubrication increases as machinery becomes more complicated, more power is applied, and greater accuracy and longer life are demanded. Some of these latter reasons have turned many machine builders to the use of ball and roller bearings, which are installed quite as often to insure uninterrupted service and freedom from lubrication ills as to save power.

Machine control is another factor which is claiming its share of attention. Hand-cranking of tables, carriages, and slides is being replaced by fast feed movements, controlled by handy levers or push buttons, which save both the time and energy of the operator.

Many other labor-conserving devices, such as chucks and clamps, operated mechanically, hydraulically, electrically, or by compressed air, are coming into use and are rapidly superseding those manually operated.

Entire rooms occupied by machines working on cast iron are served by dust-collecting systems which clear and change the air, keep the floors clean, and minimize the necessity for brushing fixtures.

Increasing attention is being given to the elimination of accidents by guarding dangerous mechanisms, and specially trained men are being employed to look for and correct hazardous machines and practices. All geared heads and single-pulley drives, for example, increase the operator's safety.

Hopper and magazine feeds are becoming common on high-production machines for light and medium-weight parts.

The iron foundry is coming more and more to the use of machinery. Conveyor systems, mechanical sand cutters, sand slingers, mechanical transportation of molten iron, and centrifugal casting of pipe are examples of advanced practice in this field. Some progress is also being made in the development of long-life molds.

Developments in Design of Basic Machines

In the design of lathes, mention might be made of one huge turning machine recently built which swings 300,000 lb. between centers and has 8 electric motors and a 36-in. grinding machine built on a carriage for use anywhere along its 45 ft. of working length. Other new lathes include automatic features, multiple-feed slides, and single-pulley drives, and on at least one of these machines the work is fed automatically from a magazine.

Planing machines are being provided with power fast traverse, faster cutting and return speeds, and better lubrication.

Milling machines now have stiffer over-arms, fast power table feeds and motors inside the column. The special and manufacturing types have been developed to do a wide variety of work; in some cases they compete with the planer in the job shop, while in others they operate continuously on quantity production. The development of these manufacturing millers has been of prime importance to some of our industries.

For drilling, we have more rigid machines, higher-speed machines, and more sensitive machines. Multiple-spindle drills (both standard and special) are being built for larger production. If quantities warrant, it is usually possible to secure a machine, made up of semi-standard units, to drill all the holes in a part from almost any direction.

The Important Trends in Grinding and Lapping

Grinding as a shop process has been developed remarkably during the past few years. One of the newest and most outstanding of these developments is the centerless grinder. The unusual production and precision possible with this type of grinding machine have opened up wide fields for its use. Improvements on internal grinders extend from an attachment on a universal grinding machine to an almost automatic machine which is self-gaging, self-dressing, and self-feeding. Cylindrical grinders are being made with better bearings, better lubrication, and greater ease of control. Some auto-loading machines have been built for special production. Wide-wheel straight-in grinding has come into favor on some varieties of work. Extremely powerful and accurate surface grinders are now being built. One of these has a 100-hp. drive, while another has an automatic sizing device and is arranged to finish the work in one pass under the wheel. The grinding of threads on taps, gages, hobs, etc. has been a development of recent years, and some progress has been made in the grinding of gears. Disk grinding, which has been developed to a high state of perfection, is an important operation in many industries.

Mechanical lapping has filled a need for greater precision and better finish, and machines have been developed to lap both flat and cylindrical parts with great accuracy and high finish. It is possible by this method to economically produce work which is accurate to fractions of a ten-thousandth part of an inch.

Development of Special Machines Has Been Significant

Besides the general classes of machines mentioned, an endless variety of more or less special machines for centering, tapping, milling, threading, polishing, buffing, stamping, etc. is being produced.

The immensely increased use of pressed metal, which calls for better and larger presses, has led to the recent development of machines which duplicate automatically blanking and forming dies, iron patterns, molds, and engraved work.

To facilitate jig and fixture work there are now available precision boring machines which take the guessing out of this line of work and effect a great saving in cost.

The use of automatic machinery has extended to the heat-treating shop, where various mechanical devices make this phase of manufacture more accurate and economical, and more pleasant for those engaged in it.

There have been accomplishments in the fields of standardization and research which would fill many pages if elaborated upon.

One of the most important developments has been that of precision measuring. Some time ago we passed from the caliper to the micrometer. Now we are passing from the micrometer to the precision gage block, the sensitive comparator, and light interference as bases for close measurements in the shop. These accurate instruments and tools have gone far toward making real interchangeable manufacture possible at a low cost. With the increasing demand for closer limits in shop work, it is indeed fortunate that a standard of measurement can be referred to which is many times more accurate than is actually required.

Along with the mechanical progress made in machine-shop practice, there has been a corresponding improvement in human relations in the shop. Lighting, ventilation, cleanliness, and safety are planned into modern shop construction. Hospitals are installed to care for those injured and, in addition, to guard the general health of workers. Schools and apprenticeship systems have been highly developed to educate the coming generation.

W. F. DIXON, *Chairman.*

Progress in Materials Handling

Contributed by the Materials Handling Division

Executive Committee: James A. Shepard, *Chairman*, P. E. Stotenbur, *Secretary*, H. V. Coes, W. F. Hunt, Robert Brooke Lea, and James Leroy Haynes

MATERIALS handling, according to our present conception, is an art pertaining to the transmission of commodities from stage to stage in the processes of production, or to their movement through relatively short distances in agriculture, lumbering, mining, manufacturing, construction, transportation, merchandising, and warehousing.

Relation of Materials Handling to Industry

Modern practice in industry trends steadily toward specialization and consequent subdivision of productive processes, with its incidental multiplication of intermediate movements; hence materials handling has grown to a point where it represents a considerable element in industry and in the cost of nearly all commodities. Materials handling therefore ranks in importance proportional to its relative volume and cost as compared to actual production. Handling methods bear no relation to the final quality of product so long as they are of a nature which will cause no deterioration of the articles handled. Handling methods are therefore good or bad in exact proportion to their economic efficiency; accordingly an exact knowledge of the relative economic efficiency of alternative handling methods is the one true basis for selection. Labor and incidental expenditures saved by the mechanization of handling operations are an economy equal in importance to the saving effected by mechanical substitutes in production.

As our industries are now organized, an inventory of the handling operations requisite for the production of almost any item of manufacture, covering all stages from the point of origin until it finally reaches the ultimate consumer, will usually mount to an almost unbelievable total. In a study of the handling operations involved in the production of iron castings in the foundry, conducted by Mr. Max Sklovsky,[1] it was found that, on the average, for each ton of

[1] Chief Engineer, Deere & Co., Moline, Ill. Mem. A.S.M.E.

finished castings produced, 168 tons of materials of one sort or another were required to be handled. Extending the survey to cover the handling operations involved in the production and transportation of the basic materials employed in making the castings, their subsequent machining and assembly with other materials into one of the products of the metal trades, such as an automobile or agricultural implement, according to conventional manufacturing methods, it is estimated that a grand total of 224 tons of materials is handled for each ton of finished product delivered to the ultimate consumer.

It seems probable that the above exceeds the average for products of our factories, and is obviously excessive for the products of farm forest, and mine. Nevertheless the true averages, if ever ascertained, will no doubt be impressive in the extreme.

Railway and ship loadings probably represent the closest approximation available as to the total volume of products of field, forest, mines, and factories in the United States.

Railway loadings for Class 1 railways of the United States were reported by the Bureau of Railway Economics for the year ending December 31, 1924, at 1,188,156,661 tons of 2000 lb. Statistics are not at hand covering ship loadings in the coastwise trade, or on inland waters; however, ship loadings inbound and outbound in our foreign trade for 18 principal ports amounted in 1924 to 106,914,899 tons of 2000 lb., hence we have a recorded total for railway and ship loadings of 1,295,071,560 tons. While these figures probably carry some duplication, it is unlikely that they will equal the volume of loadings for Class 2 railways and coastwise and inland ships, which are not included, and that therefore the products of our various industries at least equal the total given. Each shipment will require at least two handlings, one in loading, and one in unloading, and in many cases, as in water transportation, there will be four or more handlings. If we assume conservatively an average of $2^1/_2$ handlings chargeable to transportation, the total weight of materials handled in transportation annually will amount to 3,237,678,900 tons.

The economic effect of efficient handling methods will be indicated sufficiently for our present purpose by noting the fact that one cent per ton variation in handling costs in transportation alone develops an economic variation for the United States of more than $32,000,000 annually.

In the absence of statistics we may estimate the minimum relative average of handlings throughout the various processes of production to be three times the number chargeable to transportation, indicating a probable tonnage of materials handled in production of about 9,700,000,000 tons and an economic variation in production of $97,000,000 annually for each cent per ton variation in handling costs, and a total tonnage handled, for both transportation and production of 12,900,000,000 annually, with an economic variation of $129,000,000 for each cent of variation in materials-handling costs. The variety of commodities handled, and the wide variation in conditions under which they are handled, would seem to preclude any estimate of present average costs for handling to or from railway cars. The cost for handling to or from ships, however, is capable of reasonable approximation. Mr. Robert H. Overstreet in an article in the *Pacific Marine Review* for September, 1925, entitled Stevedoring American Vessels, reports that for Shipping Board vessels during the month of May, 1924, the cost of loading 207 vessels averaged 95 cents per ton and the cost of discharging 161 vessels averaged $1.27 per ton. The combined tonnage loaded and discharged was 674,905, giving an average cost for loading and discharging of 1.06^1/_2$ per ton. The difference in cost between loading and discharging of 32 cents per ton was apparently due to a surcharge by the stevedores for tiering cargo on the pier, or for other extra work.

Mr. Overstreet also estimates that the cost for handling cargo to and from sea-going vessels is from 20 to 25 per cent of the total direct disbursements for operating the vessels, from which we may conclude that the present volume of expense directly chargeable to materials handling in this division of transportation affords an ample field for increased efficiency.

As a general proposition, however, primary reductions in cost are sometimes but a small percentage of final results.

Efficiency in materials handling is profitable primarily to the extent of whatever direct savings may be effected. There are usually important secondary results. With efficient handling methods the volume of production, or transportation, available with a given equipment is increased, hence it may effect a further important saving through reduction in investment in plant required for performing a given service, effecting also a corresponding reduction in fixed charges. It may also reduce the time during which interest charges will run against capital invested in commodities which are in process of production or transportation, as well as the total of all inventories of goods in transit or in process of manufacture, thus effecting a still further reduction in interest charges.

It has been estimated that interest charges running against commodities in transit by the railways of the United States have been reduced to the extent of about $40,000,000 annually during the past few years through more expeditious transportation alone. While no attempt has been made to estimate the reduced capital invested in inventories of goods carried in stock by manufacturers, wholesalers, and merchants to bridge former delays in transportation, and its consequent interest charge annually, it is nevertheless conceded that it represents a very large sum.

The final total savings from all sources, direct and indirect, creditable to efficient materials handling will never be fully ascertained until our methods in analyzing the economic efficiency of industrial processes are perfected and applied to the secondary as well as primary economic problems; until engineers who direct the technical affairs of our industries control both mechanical and economic details.

Trends in Materials-Handling Methods and Equipment

As might be expected from its relative importance, there has been great improvement in materials-handling methods, particularly in manufacturing and construction, first, by arranging the various operations in proper sequence so as to minimize the handling movements required, and, second, through the substitution of mechanical for manual handling means. In some industrial establishments refinement of handling operations approximates the ultimate which is possible in the present state of the art. There are probably few plants in which consideration has not been given in recent years to handling problems, with a view to employing mechanical appliances in lieu of manual labor.

Progress has been retarded, however, through the lack of acceptable methods for comparing the saving in operating costs obtainable with a given capital outlay.

Efficient handling equipment appears to be in more general use in construction than in manufacturing, notwithstanding the necessity of erecting mechanical equipment for temporary use and part-time employment in construction work, whereas permanent placement and practically constant service is the rule in manufacturing. The comparatively wide use of mechanical equipment for materials handling found in agriculture as compared with other industries is not only interesting but instructive.

Materials Handling in the Mining Industry

In mining, apparently much remains to be accomplished in the handling methods used underground. It is estimated that in the coal-mining industry, which produces annually about 400,000,000 tons or more than 30 per cent of the total tonnage of all industries combined, more than 90 per cent of the coal mined carries a burden of from 40 to 60 cents per ton for hand-shovel labor.

The reported development of an electric motor which will operate with safety in an atmosphere charged with inflammable gases should, if it proves acceptable in practice, give a decided impetus to the mechanization of underground mining operations heretofore performed by hand labor.

Materials Handling in the Manufacturing Industries

The fundamental process of systematizing the layout of the manufacturing plant in order to provide for a continuous flow of materials with a minimum of handling operations, has become usual practice wherever new construction or reconstruction renders it possible to do so. There is also in evidence a more general realization than formerly that efficient production is possible only when the manufacturing plant is constructed to fit a carefully devised and inherently efficient industrial process which avoids unnecessary handling of product, and in which the type of handling equipment chosen

is such as will coöperate with and facilitate productive operations.

Notable progress has been made in adapting and applying conveying equipment for moving product through relatively short distances, and where a group of operations can be conducted in an uninterrupted sequence. The ability of such a handling equipment to hold the output of a group of operators to a predetermined reasonable rate of production has favorably affected production costs, while reducing the cost of handling product almost to the vanishing point.

For comparatively long movements, and those which must traverse variable routes, the electric platform, or lift truck, is finding a continually widening field of application. The lift truck, either hand- or power-propelled, with its accompanying materials-carrying platforms, finds special adaptation in moving finished machine parts which would be liable to injury through repeated handlings of individual pieces.

An internal transportation system for the industrial plant, consisting of electric or gasoline-driven tractors and trailers and usually operating on a fixed schedule, has become standard practice in plants where the tonnage of materials to be interchanged between departments or buildings is considerable. The ability of the electric truck or tractor to operate in coöperation with elevators in buildings several stories in height affords an excellent solution of an otherwise difficult problem.

For handling heavy articles the overhead traveling crane, one of the earliest instruments in materials handling, continues its supremacy as the most adaptable and efficient equipment for general handling operations. A variation in former practice is found in the increased number of cranes usually provided to serve a given area in order to reduce lost time in waiting for a crane to become available; an increase in operating speeds is also noted, this being done in order to reduce the time consumed in each operation performed.

For miscellaneous handling operations in buildings not exceeding two stories in height, and for specialized operations where lifting as well as conveying motions from bay to bay or from building to yard are essential, the monorail electric hoist, either cage- or floor-operated, seems to be indicated. Recent development has been in the direction of small floor-operated units for serving individual machines or operations, and for handling light loads formerly moved by hand.

Materials Handling in the Construction Industry

In construction work, mechanical handling of materials has become almost universal wherever the quantity to be moved is considerable. Handling methods which have become conventional in manufacturing are generally retained, with modifications in detail such as will adapt the equipment for portability; a type of motive power adapted for field operation is also substituted.

Materials Handling on the Railroads

In transportation by railway the handling of bulk materials has reached a comparatively high state of development, not only in the efficiency of the equipment available but also in the extent to which it is employed. Comparatively little progress is found, however, in methods for handling package and other goods which are transported in closed cars. The substitution of movable containers for closed cars has been employed experimentally in the transportation of mail matter, but there has been as yet no notable extension of this method.

Materials Handling at Ports and Terminals

In transportation by water, materials handling between the pier and ship is still performed by methods which are time-honored. Ship winches are still in almost universal use for hoisting cargo, and have been subject to little development except in the substitution in some cases of electric for steam power. For handling operations on the pier, electric trucks or tractors and trailers have in many instances displaced the hand truck for comparatively long movements. Tiering cargo mechanically, or loading and unloading motor trucks mechanically on the pier, has made very little progress, although practiced successfully abroad, notably at Manila, where 18 three-motor cage-controlled electric cranes and 10 two-motor floor-controlled electric monorail hoists have been successfully and profitably employed for more than a year. About New York Harbor the storage-battery electric truck, equipped with boom and electric hoist, is employed in handling and tiering cargo to some extent with satisfactory efficiency. Stacking machines have also been employed to a limited extent, but the bulk of cargo handled is still deposited on the pier deck by hand truck, either in a single layer or else tiered by hand labor.

Opportunities for the Engineer in Materials Handling

The relatively high direct cost of labor and the growing magnitude of its indirect cost under factory or other conditions requiring organized methods for its direction and control, renders every handling process in industry or transportation employing manual labor in considerable volume a potential field for improved efficiency.

In the materials-handling field the following divisions of industry present representative examples:

The mining industry, producing annually about 600,000,000 tons, of materials which at some stage are handled largely by hand shoveling at a direct labor cost of around $300,000,000.

Loading and unloading ships, involving the handling annually of more than 200,000,000 tons, and a probable direct labor cost of about $200,000,000.

Loading and unloading box cars, representing the handling of more than 360,000,000 tons annually, principally by hand labor; no reliable statistics are at hand giving record costs, but it is estimated that the probable direct labor cost is not less than $100,000,000 with a possible total of perhaps double that sum.

Opportunities for the engineer in the development of improved materials-handling practice and equipment were never more abundant than at present. Progress in the art is already sufficient to afford a wealth of example and precedent. There is already aroused a receptive public sentiment. The task of meeting a pressing need has been of necessity laid at the door of the engineering profession. We now find ourselves at the point when a decision must be reached as to how we can best discharge an admitted responsibility.

The problems which must be solved are both mechanical and economic, and any effort looking toward their solution can succeed only if properly directed and fortified by agreement with the fundamental laws of success. Mechanics is but a means for accomplishing a result. That result is and always must be, in industrial engineering, greater economic efficiency; the sinews of industry by which results are accomplished, and the rewards for accomplishment, must of necessity be acquired through approach, step by step, toward economic perfection.

Current unorganized methods for economic research have been shown to vary, according to individual selection of method, by several hundred per cent, both extremes of variation extending far into the realm of untruth. There can be no real progress until the objective toward which our efforts are directed is divested of all that is erroneous.

The Materials Handling Division has been engaged for several years in the development of a system for analyzing in advance of practical application the probable economic efficiency of industrial processes. Thereby it has given its endorsement to the doctrine that the mechanical-engineering field includes the technique of both mechanics and economics.

The system in question is referred to in the publications of the Society as The Formulas for Computing the Economies of Labor-Saving Equipment. These formulas and supporting matter are outlined in a paper presented by the undersigned at the 1925 Spring Meeting and published along with others giving examples applying the system in Section 2 of the May, 1925, issue of MECHANICAL ENGINEERING.

The methods there described are commended to engineers as a valuable aid in testing in advance the economic efficiency which may be expected from methods or equipment which have been planned but not yet put into practical operation.

Work now in Progress by the A.S.M.E. Materials Handling Division

The Division has practically completed its work in connection with its proposed system for developing the fundamental economics

of industrial processes and the formulas for computing the economics of labor-saving equipment, with the exception of a re-canvass of the subject with a view to securing criticism or suggestions which might aid in perfecting the system from a practical standpoint. Matters now under consideration comprise:

Standardization of all factors employed in the Formulas for Computing the Economies of Labor-Saving Equipment

Preparation of a Safety Code for Materials-Handling Equipment

Standardization of Loadings for Wire Rope when bent around drums or sheaves.

SUGGESTED FUTURE ACTIVITIES

Study with National Bureau of Economic Research of volume of materials being "handled," in order to indicate its relative importance.

Correlation of A Safety Code for Materials-Handling Equipment with other related safety codes.

Standardization of safety factors, preferably based upon the elastic limit of ductile materials, and standardization of unit stresses for non-ductile materials.

An official determination of scope for the materials-handling art.

Study of the opportunities for engineers and for engineering research in the materials-handling art.

Standardization of terminology.

Standardization of capacity ratings.

JAMES A. SHEPARD, *Chairman.*

Progress in Management Engineering

Contributed by the Management Division

Executive Committee: R. T. Kent, *Chairman*, C. W. Lytle, *Vice-Chairman*, Geo. E. Hagemann, *Secretary*, Sanford E. Thompson, A. B. Segur, and Park T. Sowden

IN THE FIELD of management during 1925 there have been no spectacular achievements calling for special mention. Instead, there has been a steady, quiet development and extension of the principles first laid down by Taylor twenty-two years ago.

Perhaps the one development that will make a marked impression on industrial management during the coming year is the work that has been instituted by the Division of Simplified Practice of the Department of Commerce at Washington. The wastes that have occurred in industry through the multiplicity of patterns and goods used for the same purpose, is beginning to be appreciated. It is so obvious as to require no comment that a reduction in varieties made in the plant will simplify the management problem and so conduce to better and better management. Management is directly attacking these problems of waste in industry. It has been made the subject of Management Week this year, dealing specifically with wastes in distribution, and basing the discussion upon the work of the Division of Simplified Practice just outlined.

THE NEW SCOPE FOR THE MANAGEMENT ENGINEER

The functions of the management engineer as conceived by the Management Division are set forth in a booklet just issued by the Professional Divisions, and a quotation from this may be of interest:

> Management Engineering relates to the coördination in industry of the functions of finance, purchasing, production, sales, and distribution. Although the term is commonly applied to productive enterprise, nevertheless it is applicable to other enterprises wherein production is not concerned, such as merchandising, governmental operations, etc.
>
> The work of the Management Engineer is to coördinate these various functions by the application of engineering methods, namely, the collection and analysis of facts relating to the several functions, the institution of research work relating to the various activities, the selection of the best means or methods of securing harmonious coördination of the various activities and functions of an enterprise, and the development of a balanced system or routine for carrying out coördinated activities. It should be noted that to the inexperienced, this last phase of Management Engineering appears to be the most important, and that all that is necessary to reorganize the industry and put it on an efficient basis is the development of a so-called "system." As a matter of fact, this is the least important of the functions of the Management Engineer, and is merely the tangible result of the efforts expended along the other lines of his work. The important thing to be borne in mind in considering the work of the Management Engineer is that all his problems should be approached from the engineering standpoint and solved by engineering methods.
>
> The problems that are brought before the Management Engineer are so varied in scope and nature that it is seldom possible for a single individual to have at his command a complete knowledge for their solution. For this reason the Management Engineer must have the coöperation of specialists in other lines when the particular problem at hand is in the field of these respective specialists. For example, in the metal-working field, problems of machine design, metallurgy, foundry practice, machine-shop practice, purchasing, and finance, to say nothing of the problems of advertising, sales, and distribution, arise. The man who has specialized in any one of these fields could hardly be expected to be an expert in all of the others. The work of the Management Engineer is to obtain from these specialists the necessary data and to analyze them, accord them the necessary weight in the scheme, and then coördinate the activities in each field into a harmonious, smooth-working machine.
>
> The Management Division of the A.S.M.E. has for its purpose the bringing to light and the discussion of all these factors in their various phases, in so far as they relate to the management of an enterprise, as a whole.

THE TREND OF INDUSTRIAL PSYCHOLOGY

Another development in the field of management, which, although only beginning, will nevertheless make a deep impression upon management problems, is the development of industrial psychology. From the very first, Taylor stressed the necessity of selecting the proper type of man for the work that was to be done. At that time, however, little or nothing was known of the methods of selection. Within the past few years the science of psychology, as applied to industry, has made great strides, and the records made by it in selecting the proper type of worker for the job have, in some cases, been uncanny. So important does the Management Division regard the subject of industrial psychology, that it was adopted as one of the major topics for the Annual Meeting.

THE RECURRING STUDY OF INDUSTRIAL FATIGUE

Another development in management engineering which has had greater attention in other countries than the United States is the increasing attention being paid to industrial fatigue. It is being realized more and more that one of our greatest industrial wastes is the waste of man power, and that unnecessary fatigue is one of the principal factors in causing this waste. Great Britain has, for the past five years, been conducting a research on this subject. It would seem that there is no scientific and experimental research that could be taken up by industry in this country that would be so profitable and so far-reaching in its results than one on industrial fatigue.

INTERNATIONAL ACTIVITIES IN MANAGEMENT

An encouraging feature, from the standpoint of the Management Division, is the growth of interest in management on the other side of the Atlantic. In the First International Management Congress, held in Prague, Czechoslovakia, in the summer of 1924, the Management Division had a prominent part. The purpose of this congress was to stimulate enthusiasm for modern management methods in all the countries of eastern Europe. The Second International Management Congress was held in Brussels, under the auspices of the King of the Belgians, during October of this year. This congress was a direct outgrowth of the Prague Congress. A society has been organized in Poland to further the development of modern management methods. Steps have been taken to form a permanent international committee whose duty it will be to provide for such future international management congresses as may seem desirable.

THE MANAGEMENT DIVISION OF THE A.S.M.E.

As to the work of the Management Division, its policy has been to develop a comprehensive, progressive program. Two researches, one on management terminology and the other on graphical presentation of management standards, had been under way for some time as joint society activities, with rather unsatisfactory results. The Management Division has been instrumental in turning the first of these over to one of the leading management periodicals, whose facilities for conducting such a research are superior to those of any single society or group of societies. It has been instrumental in having the second research sponsored by the American Engineering Standards Committee. Another forward step that it has taken has been the institution of a program to extend over a period of years for the development of typical production-control systems in a wide variety of industries. These are not to be offered as the best system for any particular industry, but simply as a model upon which a manufacturer in that industry can base a system best adapted to his needs. One accomplishment of the Management Division has been to compile a list of the live management topics of the day and to organize a corps of speakers who can present these topics at any meeting of any Local Section of the Society that may desire assistance.

Subjects very much to the fore are naturally the training of personnel, the training of the modern industrial executive, the training of foremen, the selection, training, and development of employees, methods of employee coöperation, and wage systems.

Another class of subjects includes industrial organization, maintenance of industrial buildings and fixed equipment, executive control, factory location, factory buildings and service equipment, control of materials and stores, cost accounts.

Still a third class of subjects in the field of the management engineer are time and motion studies, analyses of jobs, setting production rates from time studies, motion-study standards, and other standards of management.

In fact, the opportunities for the management engineer would appear to be extremely diversified. Almost every industry is involved, and considering the general trend to eliminate waste and simplify practice, it would seem that the opportunities for the management engineer are extremely interesting at this time.

R. T. KENT, *Chairman.*

Progress in Oil- and Gas-Power Engineering

Contributed by the Oil and Gas Power Division

Executive Committee: Edgar J. Kates, *Chairman*, L. H. Morrison, *Secretary*, Elmer A. Sperry, Robert Rennie, Geo. D. Pogue, and John W. Morton

THERE is no more efficient method of producing mechanical power from petroleum than that employed by the modern oil engine. Similarly, the gas engine using blast-furnace gas to produce electric power and to compress blast air, does more work per unit of gas than any other known type of machine.

The field of oil and gas power is ever widening. Starting with engines used only for stationary plants, it next was developed for marine use. A start has lately been made in the application of oil power to driving locomotives, tractors, and automobiles, and before long we shall undoubtedly see oil engines driving airplanes.

15,000 HP. NOW REACHED IN ONE UNIT

Not many years ago the field of application of the oil engine was greatly restricted by the comparatively small capacity of the units available. Power users requiring thousands of horsepower were not interested in oil engines whose rating was of the order of hundreds of horsepower. This prevented the use of oil engines in central stations except those of small size, and limited the marine use to comparatively small and slow freight vessels. However, that condition is now rapidly passing, and the experience gained with the smaller sizes has brought about the development of successful oil engines of much larger sizes which are now invading fields formerly dominated by steam power.

Among examples of large-size engines which have been brought out during the past year are the following:

1 The motor liner *Asturias* built by Harland & Wolff of Belfast, having a gross tonnage of 22,000 and a speed of 15½ to 16 knots. This ship contains two engines of the Burmeister & Wain type rated 7500 b.hp. each at 115 r.p.m. The engines are double-acting four-stroke-cycle and have eight cylinders 33 in. in diameter by 59 in. stroke. An idea of the dimensions is given by the height of 36 ft. from the bottom of the bedplate, a length of about 60 ft., and a weight about 700 tons.

2 A 15,000-hp. 9-cylinder two-stroke-cycle double-acting Diesel engine is being built by Blohm & Voss of Hamburg for a power plant in Hamburg.

CURRENT INSTALLATIONS PRESENT NOVEL FEATURES

Several interesting installations are under way or have recently been completed. Among them may be mentioned:

1 The U. S. Shipping Board has on order 18 large Diesel engines ranging from 2700 b.hp. to 3000 b.hp. each for converting existing steamships to motorships. Nine of these engines are single-acting four-stroke-cycle, four are single-acting two-stroke-cycle one is double-acting four-stroke-cycle, and four are double-acting two-stroke-cycle. Note the trend toward double-acting engines. A few years ago single-acting engines were quite the rule, but in this order the double-acting engines comprise one-third of the total.

2 Three Diesel engines of 3750 b.hp. each have been ordered for a new power plant at Miraflores in the Panama Canal Zone, as auxiliary to the Gatun hydroelectric plant. These engines are of the Nordberg two-stroke-cycle single-acting design having 6 cylinders 29 in. in diam. by 44 in. stroke, running at 125 r.p.m., and direct-connected to 25-cycle generators of the flywheel type. These are the largest individual engines so far built in the United States.

3 The United States Helium Production Plant at Fort Worth, Texas, is operated by seven 500-hp. Bruce-Macbeth natural-gas engines which supply power to compress the natural gas to 3000 lb. per sq. in. for extracting the helium. The engines consume about one-eighth of the gas processed, the remainder going back into the mains. The low-pressure steam required is furnished by exhaust-gas economizers connected to the engines.

4 The Port of Portland's 30-in. pipe-line dredge *Clackamas*, which is one of the largest and most efficient dredges ever built, has been powered with two 800-b.hp. and two 900 b.hp. McIntosh & Seymour Diesel engines driving electric generators, which in turn operate the electric motors driving the dredging pump, the cutter, and the auxiliary machinery.

REMARKABLE INCREASE IN MARINE APPLICATION

There has been a remarkable increase in the number of motorships being built as compared with steamships. The gross tonnage of motorships under construction in September, 1921, was but one-tenth of the steamship tonnage, whereas in June, 1925, it had tripled and was practically equal to the steamship tonnage. It is apparent that in the present period of depression in the shipping business the economic advantages of the motorship are being generally recognized.

Table 1, from Lloyd's Register, gives data on the marine engines under construction for new ships in June, 1925, throughout the world. It will be seen that the power of the oil engines is almost as great as that of reciprocating steam engines and steam turbines combined.

The total power of marine oil engines being built in August, 1925, was approximately 918,000 i.hp. Of the various oil-engine

TABLE 1 MARINE ENGINES UNDER CONSTRUCTION, JUNE, 1925

Country of construction	Steam engines: Reciprocating No.	Steam engines: Reciprocating I.hp.	Steam engines: Turbines No.	Steam engines: Turbines s.hp.	Oil engines No.	Oil engines I.hp.	Total No.	Total Hp.
Great Britain and Ireland	201	344,315	16	158,114	57	206,773	274	709,202
Denmark	3	2,100	..	....	33	125,950	36	128,050
France	17	67,700	3	67,000	5	21,100	25	155,800
Germany	24	39,775	3	28,000	57	227,026	84	294,801
Holland	20	28,980	1	3,000	11	62,465	32	94,445
Italy	14	18,950	3	44,000	10	36,720	27	99,670
Japan	6	15,170	..	....	1	6,100	7	21,270
Norway	21	17,150	..	....	1	2,800	22	19,950
Sweden	4	2,530	1	2,930	89	57,000	94	62,460
Switzerland	....	....	..	....	11	46,940	11	46,940
United States	3	5,450	6	46,600	8	14,790	17	66,840
Other countries	10	17,850	1	3,500	1	600	12	21,950
Total	323	559,970	34	353,144	284	808,264	641	1,721,378

types, the 4-stroke-cycle single-acting was still by far the most popular. The relative standing of the various types was as follows:

Four-stroke single-acting	48 per cent
Two-stroke single-acting	23 per cent
Four-stroke double-acting	23 per cent
Two-stroke double-acting	6 per cent

There is at present no sign whatever of the standardization of any one type of oil engine for marine drive.

The motorship of today presents a variety of drives designed with the object of reducing weight or space, or of increasing propeller efficiencies. These are:

a Direct drive
b High-speed engines with gear transmissions
c High-speed engines with hydraulic transmissions
d Diesel-electric drive.

The last one is gaining ground in this country for use on smaller vessels, tugs, and ferry boats. However, for larger vessels the direct Diesel drive is still well in the lead, and especially the long-stroke engine introduced for converting steamships and saving the old propeller equipment.

Locomotive Application

There has been no noteworthy advance in this country in the application of Diesel engines to locomotive drive since the 300-hp. Ingersoll-Rand 60-ton locomotive except for a 1000-hp. locomotive just completed by the Baldwin Locomotive Works employing an oil engine of unusual design hitherto unapplied to practical use. This locomotive is now in experimental use on the Philadelphia & Reading Railroad.

In Europe, however, the tempting improvement in overall efficiency promised by the oil-engine locomotive (about six to eight times that of the steam locomotive) has been the spur to many interesting developments. In Germany two 1200-hp. Diesel locomotives have recently been built. Each of these is powdered by a six-cylinder ($17^3/_4$ in. in diameter by $16^1/_2$ in. stroke), 450-r.p.m. M.A.N. Diesel engine weighing 29 tons. One of these locomotives has electric transmission and the other has gear transmission. The total weight of the Diesel-electric locomotive is 137 tons, or 230 lb. per hp. This is a development of the original Diesel-electric locomotive built in Russia in 1909 from the designs of Dr. Lomonossoff.

Another interesting type of Diesel locomotive is being built by the M.A.N. works using the Diesel engine to drive an air compressor. The compressed air is heated by the exhaust gas from the engine and then develops its power in the ordinary type of locomotive cylinders. It is expected to produce at the locomotive wheels 27 per cent of the power represented by the heat value of the fuel.

The real problem in the application of oil engines to locomotive drive is hardly in the design of the engine itself, but rather in the mechanism for transmitting the engine power to the locomotive drivers. The electric drive answers the demand for high starting torque and ease of control, but suffers from too much weight. That is the reason for the search for improved forms of other types of transmission.

Gas Blowing Engines Have Been Very Efficient

The first American blast-furnace-gas-engine plant was installed by the Lackawanna Steel Company at Buffalo in 1903 to 1905, but according to C. G. Sprado there are now in American steel plants, 118 gas blowing engines having a total capacity of 3,600,000 cu. ft. per min. and 110 gas-electric units having a capacity of 275,000 kw.[1]

Gas blowing engines are generally of the four-stroke cycle double-acting type with the air cylinders directly in line with the gas cylinders; they are of the tandem type, having two double-acting gas cylinders for each double-acting air cylinder. The design of the air cylinders or "tubs" has changed from positively operated inlet and discharge valves to plate valves. Fifteen years' experience has shown that gas blowing engines are fully the equal of steam engines in reliability.

An Airplane Oil Engine is under Test

An oil engine designed for aircraft use is now on trial at the Naval Aircraft Factory, Philadelphia. This is known as the "Attendu" engine, the experimental model being a two-cylinder, airless-injection, self-igniting, two-stroke-cycle engine, designed to develop 125 hp. at 1800 r.p.m. The engine weighs $3^1/_2$ lb. per hp. and is said to run with clear exhaust, burning 19 deg. B. fuel.

Organized Publicity for Oil and Gas Power

In April, 1925, the Oil and Gas Power Division of the A.S.M.E. sponsored a national movement known as Oil and Gas Power Week. Its object was to focus nation-wide attention on the part of engineers, operating men, chemists, and the industries on recent progress and on immediate possibilities in the utilization of oil and gas for power purposes. The coöperation of fifteen national societies of engineers and chemists, also of three government bureaus and various local technical societies, was brought about, with the result that 130 meetings were held throughout the country attended by about 11,000 people. A printed program was published containing the names of authors, papers, and addresses at all of the various meetings, and a copy was given to each person attending a meeting. Other copies were distributed elsewhere, with the result that the subject of oil and gas power received widespread publicity.

An Organization to Record Accidents is Necessary

A valuable document is the Technical Report for 1924 of the British Engine, Boiler, and Electrical Insurance Co. Ltd., prepared by Michael Longridge, Chief Engineer. This report contains accounts of breakdowns and failures of steam engines, oil engines, boilers, electrical equipment, etc., selected from the casualty list of the year either on account of some interesting peculiarity or as suggestive to manufacturers and users of the various sorts of machinery covered. Each accident is reported in detail, with drawings, photographs, photomicrographs, etc., and the evidence is closely analyzed to bring out the cause.

A report of like character to cover similar classes of accidents in this country is much to be desired.

Trends in Cycles, Processes, and Equipment

Double-Acting Principle. Reference has been made before to the increasing use of the double-acting principle. This applies to both the four-stroke-cycle engine and the two-stroke-cycle engine, and is of course a natural development to be expected where large powers are required. Among recent applications of the double-acting principle may be mentioned the Worthington two-stroke-cycle, the Burmeister & Wain four-stroke-cycle, the M.A.N. two-stroke-cycle, and the Werkspoor two-stroke-cycle engines.

Solid Injection. Oil-engine development tends more and more to the elimination of the air compressor for supplying air to inject the fuel. Not only are more manufacturers adopting the principle of airless or solid injection, but this principle is being applied to larger and larger sizes.

The oldest Diesel-engine manufacturers of all, the Maschinenfabrik Augsburg-Nürnberg A.G. (known as the M.A.N.) have developed an airless-injection engine for small sizes. Sulzer Bros., of Switzerland, who have been building air-injection Diesel engines for 25 years, have adopted the airless-injection system for a line of small engines.

As an example of the application of solid injection to larger sizes, the De La Vergne Machine Company now has in regular

[1] Economy of Gas Blowing Engines, by C. G. Sprado, presented April 20, 1925, during Oil and Gas Power Week, at Tonawanda, N. Y.

production solid-injection engines of 1000 hp. using six cylinders 21 in. in diameter by 30 in. stroke.

Superchargers. These have been increasingly used for:

1 Increasing power and reducing first cost

2 Providing reserve power for peak loads.

The gain in power through supercharging is ordinarily 10 to 15 per cent, though on some German installations a gain of 30 per cent has been claimed without injury to the engine.

Centrifugal compressors are now being widely used for supercharging. This type of supercharger has been highly developed by the General Electric Company in this country and by Brown, Boveri & Co. in Switzerland.

Independent Auxiliaries. There is a tendency in the case of large engines to make independent units of the blast-air compressors, and also of the scavenging compressors in the case of two-stroke-cycle engines. The Motorship *Gripsholm* contains two 6750-hp. Burmeister & Wain four-stroke-cycle double-acting engines, no compressors being mounted on the main engines. Injection air is furnished by three air compressors driven by 600-hp. Diesel engines. It may be noted in passing that this ship also contains three 500-hp. Diesel generating sets, making a total Diesel installation of 16,800 b.hp.

The two-stroke-cycle Sun-Doxford engines of the ore carriers *Henry Ford II* and *Benson Ford* receive their scavenging air from centrifugal compressors built by the General Electric Company which are rated 12,000 cu. ft. per min. at 2.5 lb. pressure and are driven by electric motors developing 180 hp. The principal advantages to be obtained aboard ship with this method of scavenging are saving in weight and space, and also better control of the scavenging air when maneuvering the ship.

A centrifugal compressor connected through gears to the engine shaft furnishes scavenging air to the 1000-hp. two-stroke-cycle Knudsen engine used on the Baldwin Diesel locomotive previously referred to. This is a General Electric compressor rated at 4500 cu. ft. per min. at 2.5 lb. pressure.

Jacket-Water Systems. Although the harmful effects of scale in oil-engine water jackets have long been known, the practice in the past has generally been to permit the scale to form but to remove it occasionally before serious damage resulted. However, a more logical procedure is now being followed in many cases, which consists in using soft water in the engine jackets, thus preventing the formation of any scale whatever. Such soft-water systems usually consist of a closed-circuit system in which the same supply of soft water is used repeatedly, and after being heated in the engine jackets is recooled by means of pipe coils or other heat exchangers which deliver the heat to the raw-water supply. There are a number of cases on record where plants which had suffered repeated cracking of cylinder heads caused by scale completely overcome the trouble by adopting enclosed cooling systems as above described.

Centrifugal Purifiers for Fuel Oil. Centrifugal purification of heavy fuels before entry to the engine has received impetus, particularly aboard ship. In order that the separation of water and dirt may be rapid and effective, it is necessary to preheat the oil before admitting it to the centrifuge, the preheated temperature ranging from 120 deg. fahr. in the case of comparatively light fuels, to 210 deg. fahr. for very heavy fuels. Such purification of the fuel has been found to result in greatly reduced wear of pistons and liners, and longer periods of good seating of the exhaust valves and spray valves.

Air Filters. Interest is increasing in the use of air filters for cleaning the intake air of oil and gas engines in order to reduce wear on liners and pistons, and also possibly to increase the life of the exhaust-valve seats between regrindings. In industrial districts the dust content is about 2 to 4 grains per 1000 cu. ft. of air. This is equivalent, in a 200-hp. engine running continuously, to $3\frac{1}{2}$ to 7 lb. of dust and grit drawn into the cylinders each week.[1]

Measurement of Exhaust-Gas Temperatures. On a multi-cylinder engine it is of course desirable that each cylinder should carry the same proportion of the total load on the engine. This is especially true when the engine is operating near full load, as otherwise one or more cylinders may be heavily overloaded, resulting in unsatisfactory performance. A simple means of checking the distribution of load among the various cylinders is to measure the temperatures in the individual exhaust outlets. If the engine is in good mechanical condition, with tight exhaust valves and piston rings, also with correctly timed fuel injection, the temperature in the exhaust outlet of any cylinder will vary practically in direct proportion to the load on that cylinder. In a test on one engine it was found that the exhaust-gas temperature varied 5 deg. fahr. for each 1 per cent change in load over the whole range of 25 per cent to 110 per cent of rated load. The exhaust outlet temperatures therefore serve as an excellent check on the engine performance, and pyrometer equipments are now being widely used for this purpose.

Utilization of Waste Heat. Within the last few years exhaust boilers have received considerable attention in this country, especially for marine use. While it is of course desirable to try to save some of the heat rejected in the exhaust of an oil engine, the commercial advantage is limited by the comparatively low temperature of the exhaust gases due to the high thermal efficiency of the engine. Consequently to recover any large proportion of the heat in the exhaust, requires a large and expensive exhaust boiler whose first cost, maintenance charges, space occupied, weight, etc. may or may not be justified from a commercial point of view.

In this respect the oil engine differs from the gas engine, as the heat in the gas-engine exhaust is very much greater and is often well worth recovery.

Another possible application of the exhaust heat is to employ it in a gas turbine driving a blower for supercharging the engine. This system, while the subject of experiment, has not yet been commercially adopted.

A Few of the Problems Awaiting Solution

Among the outstanding mechanical problems in the field of oil- and gas-power engineering are:

1 Reduction in weight and cost of oil engines by
   - *a* Improvement in materials used
   - *b* Improvement in design affecting simplicity and standardization for the purpose of reducing manufacturing costs
   - *c* Supercharging.

2 Standardization of accessories to permit their purchase at lower prices.

3 Obtaining information from the users of oil engines to help designers and manufacturers improve them. An organization of oil-engine users, similar to the Diesel Engine Users Association of Great Britain, is much to be desired in this country.

4 A real survey of the relation of the oil engine to the economic production of power, and conclusion as to limitations, etc.

5 Quality and grades of fuel obtainable in the future for oil-engine use.

6 Purification of future fuels for oil engines and study of the problems in burning heavy oil.

7 Elimination of harmful effects of critical speeds and torsional vibrations in multi-cylinder engines.

8 Prevention of harmful heat strains in cylinder heads, pistons, and liners of large oil engines.

9 Application to large oil engines of airless injection of fuel.

10 Improvement of combustion efficiency of airless-injection oil engines, resulting in greater m.e.p. and lower fuel consumption.

11 Improvement of thermal and mechanical efficiencies of oil and gas turbines, with special reference to metallurgical research for improved materials.

12 Development of oil engines and transmissions suitable for locomotive drive.

13 Development of oil engines and transmissions suitable for truck and tractor drive.

14 Utilization of waste heat.

15 Life of engine parts as related to (*a*) piston speed and (*b*) revolutions per minute.

Oil and Gas Research Now in Progress

There is little information available regarding research work now in progress on oil and gas engines, although a great deal of work is being done in connection with gasoline engines. In the oil-engine field the following researches are under way:[1]

[1] *Oil Engine Power*, July, 1925, p. 397.

[1] On page 1140 will be found a brief reference to the present status of the work of the National Advisory Committee for Aeronautics.

1 Oil-Spray Characteristics for Solid-Injection Oil Engines—at Engineering Experiment Station, Pennsylvania State College, State College, Pa.

2 Analysis of Indicator Diagrams of Internal-Combustion Engines—at Engineering Experiment Station, Pennsylvania State College.

3 Solid-Injection Oil Engines for Aviation Use—at Langley Field Memorial Laboratory of National Advisory Committee for Aeronautics, Langley Field, Va.

4 A High-Speed Indicator has been invented by Prof. H. M. Jacklin, of Ohio State University, Columbus, Ohio, and has been used on a 1000-r.p.m. Delco light engine.

IMPORTANT PUBLICATIONS

A bibliography on oil and gas power prepared by the Engineering Societies Library is appended to the original of this report. Particular reference, however, may be made to the papers presented before the Diesel Engine Users' Association of Great Britain. These papers are almost always of high quality and are particularly valuable because they present their subjects from the viewpoint of the engine user rather than from that of the engine manufacturer.

The chairman gratefully acknowledges the assistance of J. W. Morton, L. H. Morrison, W. Mulberon, Wm. T. Magruder, and D. M. Palm in the preparation of this review.

EDGAR J. KATES, *Chairman.*

Progress in Steam-Power Engineering

Contributed by the Power Division

Executive Committee: Frank S. Clark, *Chairman*, Lewis F. Moody, *Vice-Chairman*, John A. Hunter, *Secretary*, H. B. Reynolds, and N. E. Funk

THE almost universal adoption of electricity as the means of driving machinery, except in the case of the railroads, and the constantly growing use of central-station power by the industries, narrows the field to be covered practically to a discussion of the advance in the art of producing central-station power. This is a perfectly sound condition and works to the bettering of the efficiency of the industries and of the central station by relieving industry of what previously has been considered a necessary evil in the making of a product and concentrating the production of power where it will be the only commodity produced, and consequently will be the most efficiently done. There are, of course, exceptions to this general statement where certain industries demand large amounts of steam for processes or which have as by-products materials which can be used for the production of steam power with a resultant saving of fuel—which is by far the most expensive item of cost in the production of steam power.

The past year has been characterized more by a further carrying out and perfection of developments begun during the past few years, than by the production of anything essentially new in the industry.

THE TREND TOWARD THE 100,000-KW. SINGLE UNIT

The growing centralization of the production of power by steam has resulted in enormous increases in the generating capacities of the different stations and of their individual units. These have made economically possible refinements in the processes of steam production and utilization that could not have been employed in the smaller plant. Stations have been placed in operation during this past year with capacities of 50,000 kw. in one unit on one shaft, and of 60,000 kw. in two units in tandem on one shaft or cross-compounded on two or more shafts. At least one unit of over 70,000 kw. has been ordered, and manufacturers and users are talking already in terms of units of 100,000 kw. and more. There has been a general adoption of the direct-connected auxiliary generator for station auxiliary service, backed up usually by a small emergency house turbine.

As the steam turbine is most efficient at high vacuum, a great deal of study has been given to the condensing equipment, with a view to a better utilization of the cooling surface installed. Although the decreased steam consumption of the turbine and the bleeding of steam at successive stages for feedwater heating have lessened the amount of steam to be condensed per kilowatt of capacity, the modern condenser has increased in size to 70,000 or 80,000 sq. ft. of surface, requiring enormous quantities of water for condensing purposes.

EXPERIENCE WITH PREHEATERS IS DEVELOPING

A great amount of study is being given to the so-called "heat balances," and to the source of power for auxiliary equipment. The use of the regenerative cycle, involving the bleeding of steam from the main units for the heating of boiler feedwater, is now common practice and results in a saving of heat which would otherwise have gone to waste. The water is heated by this method to a point where there is less work left for the economizers to do, consequently these have been discontinued entirely, or have been decreased in size and the flue gases leave them at higher temperatures than formerly. To recover this heat in the gases recourse has been had to air preheaters, and they are now coming into general use. This equipment not only recovers heat that would otherwise go to waste, but also aids in improving the efficiency of combustion by increasing the temperature of the air used for this purpose. Several different types of preheaters are now in use, but to date experience is so limited that no comparison can be made as to their relative merits.

THE FUEL SITUATION IN THE STEAM PLANT

Coal has been and will continue to be the chief fuel used in the production of steam. The greatly increased cost of coal has caused a careful study to be made of the most efficient means of burning it. Pulverized coal, long used in the cement industry, is being adopted more and more for modern steam stations. During the past year at least six large plants using this fuel have been put into service, and more are under construction. Much study is being given to the improvement in equipment for the preparation of the coal. Mills have been increased in capacity with a decrease in power consumption per ton of coal pulverized. The old rotary drier has given way to the waste-heat or flue-gas drier, and this is losing ground to the steam drier using steam bled from the main generating units. Rapid strides are being made in the development of burners and in the design of furnaces. Burners are being developed in which the air and coal are mixed in proper proportions before introduction into the furnace, with consequent shortening in length of flame and decrease in the size of furnace volume required for proper combustion. The so-called "Unit System" of preparation and burning is being used more and more in the smaller stations. For the large stations the separate preparation plant is universally used.

TRENDS IN FURNACE-WALL DESIGN

The increasingly severe service imposed on furnace walls by the high rates of combustion now becoming common practice has prompted greater study of the design of the furnace and of the materials used in the construction of its walls. The study of refractory materials originally undertaken by a group of engineers and operating companies has recently been taken over by the A.S.M.E. and will be actively carried on. Furnaces are being constructed with hollow or ventilated walls as a means toward increasing their life. The use of water-cooled walls connected into the boiler circulating system is also becoming more common. By these means the life of furnace walls is being increased, with consequent increase in length of service of the boiler and decrease in maintenance costs. Much work has been done in the development of systems of combustion control to regulate the operation of

the combustion equipment in accordance with the demand for steam and to proportion the supply of fuel and air to meet the demand with a maximum possible efficiency.

ACHIEVEMENTS WITH HIGH STEAM PRESSURES

Steam-generating equipment has kept pace with steam-utilization equipment. To attain increased thermal efficiencies steam pressures have been increased successively from 200 lb. to 300 lb., 350 lb., and 400 lb. This latter pressure appears to be about the limit for boilers of present-day standard design. Above this point the advantages of increased pressure decrease rapidly unless combined with the reheating of the steam at some point during its expansion. This introduces many complications which tend to prevent its use in any but the very large plants. These have been put in successful operation, however, in at least three stations with pressures at about 600 lb. and employing the reheat principle, and several more are in course of construction. To the engineering firm of Sargent & Lundy may be given the credit for this pioneer work, together with the Babcock & Wilcox Company, who designed and constructed the boilers, and the General Electric Company, the Westinghouse Electric & Manufacturing Company, and the C. A. Parsons Company, Ltd., who have designed and constructed the turbines operating at this pressure.

Going beyond these, but involving the same principles, is an installation in the Edgar Station of The Edison Electric Illuminating Company of Boston, at Weymouth, Mass. This station utilizes two pressures, the main portion operating at 375 lb. In addition to this, there are installed a boiler and a turbine operating at 1200 lb. pressure. The turbine exhausts at 375 lb. through a reheater located in the setting of the 1200-lb. boiler into the steam system of the main portion of the plant. This installation required pioneer work at every turn in the theoretical design and in the practical execution of the work. The boiler is of unique construction, the drum being made from a forging with walls $4\frac{1}{2}$ in. thick. Intricate problems had to be worked out to provide against possible operating contingencies. Special care was taken in the various manufacturing processes, the X-ray being called into service for the examination of all steel castings used in the work. To Mr. I. E. Moultrop of The Edison Electric Illuminating Company of Boston and Stone & Webster, Inc., may be given the credit for the decision to undertake this pioneer development. Gen. Tracy Dickson of the Watertown Arsenal coöperated in the X-ray examination, the actual work being done by Dr. Lester of the Arsenal staff. The boiler is the work of the Babcock & Wilcox Company, and the turbine of General Electric Company.

HIGH STEAM PRESSURES WILL REJUVENATE PLANTS

The operation of this pioneer installation will be closely watched by the industry, as its success will provide a means for the rejuvenation of existing low- and medium-pressure plants by the installation of high-pressure units and boilers in such plants, the high-pressure units exhausting through reheaters with the main steam systems of the plants as is done at the Edgar Station. The use of these higher pressures has made a demand for accurate knowledge of the properties of steam beyond the range of the present steam tables, and this work, investigated by Mr. George Orrok and sponsored by the A.S.M.E., has been undertaken jointly by the Bureau of Standards, the Engineering School of Harvard University and the Massachusetts Institute of Technology and has been carried on for over a year by Messrs. Nathan S. Osborne, Harvey N. Davis, Frederick G. Keyes, and their associates.

MATERIALS, PIPING, FITTINGS

Existing standards for piping, valves, and fittings were not developed for pressures above 250 lb. A committee of this Society has been at work for two years in conjunction with representatives of manufacturers in developing suitable standards for steam pressures up to 1500 lb. This work is now practically completed, and will result in much-needed uniformity in the design of these necessary adjuncts to the production of steam power.

Study is also being given to the production of materials that will be suitable for temperatures above 700–725 deg. fahr., which is about the practical limit for present available materials. Where these are developed working steam temperatures will be increased, with resulting greater economies in power generation.

"A POUND OF COAL PER KILOWATT-HOUR"

As stated before, the past year has been one of perfecting developments of several previous years. The results are being shown already in the early operating records of some of the newer plants and prove that the slogan "A Pound of Coal per Kilowatt-Hour" is no fanciful statement, but that its attainment is actually at hand.

FRANK S. CLARK, *Chairman.*

Progress in Fuels Engineering

Contributed by the Fuels Division

Executive Committee: O. P. Hood, *Chairman*, H. W. Brooks, *Secretary*, Edw. N. Trump, E. C. Schmidt, David Moffat Myers, and Edwin Jowett

THE general fuel situation shows sufficient variety in the combination of events to make it different without introducing any distinctly new detail. Price, source of supply, wage disputes, strikes and shutdowns, and competing fuels are the variable elements, as usual. Steam coal has been relatively cheap. Oil prices have advanced, and the swing to the use of oil for major purposes has been checked. Users of coal have in many cases found it necessary to buy unfamiliar coals. In general, the new coal has been of good quality, and the changes have made but little disturbance. We have had major labor difficulties, distressing in some districts, but with less public concern than usual because of adequate supplies from new sources. More people have probably given serious consideration to their fuel problems than in former years.

THE TRENDS IN DOMESTIC HEATING

At the present time there is a considerable drift away from habitual methods of using fuel for house heating. Increasing cost of anthracite has had two opposite effects, a part of the people taking advantage of the relatively cheap semibituminous and bituminous coal, while others have been willing to stand an even greater cost than heretofore, in the hope of obtaining a superior service by burning oil. That this departure from habit is not due solely to the high price of anthracite is evident from the fact that many oil burners are going into homes in strictly bituminous districts. It seems to indicate the fact that house heating has joined the long list of American luxuries that the average man aspires to enjoy. To escape dust, dirt, ash handling, coal shoveling, and intermittent attention to a messy job in the basement, it has been demonstrated that people will pay a good round sum for installation and operating expense. Whether we have oil for long or not for such purposes, the way has been paved for general house heating by gas at some future time when engineers shall have provided suitable devices and enterprise has backed a gas undertaking designed for this purpose.

A very considerable amount of ingenuity and good effort has been put upon the development of domestic oil equipment, with the result that when they are good the service is very, very good, but when they are bad it is "horrid." A beginning has been made in the development of mechanical coal stokers for small house-heating plants, a problem much more complicated than that of developing an oil burner, but one having even greater commercial possibilities and usefulness.

The return of cheap coal and increasing prices for oil has reversed the trend toward oil burning where coal can give equal service. Fuel oil is essentially a by-product that must be gotten rid of as produced, so that the price will follow and frequently cross the price level set by equal service from coal, and will always be just sufficient to dispose of it. The demand for gasoline, now the dominant factor in the petroleum industry, will be met when necessary by restricting the output of fractions now used by domestic oil burners, gas companies, and fuel-oil users in the order named.

POWDERED COAL AND REDUCTION OF FURNACE VOLUMES

In the use of powdered coal the most rapid development continues in its application to steam boilers. Pulverized fuel is given a thorough study before deciding on the method of burning fuel for each new steam plant of any size. Where applicable the economic results obtained have verified expectations. The rate of increase in installations has been maintained. Pulverized fuel appears to possess a distinct advantage in handling poorer and cheaper grades of coal. To an increasing extent the boiler room has become a laboratory for steam generation, attracting talent and having highly developed control apparatus that gives promise of further development into automatic regulation of an order approaching the automatic regulation of steam-using devices. This is possible with the small amount of fuel in the furnace when using fluid fuels. There has been cumulative evidence of sustained high operating efficiencies and a better understanding of operating difficulties and furnace failures. The year has seen remarkable progress in the direction of reducing the combustion space needed in powdered-coal furnaces by the use of great turbulence of gases. The rate of reaction between carbon and oxygen at any temperature above that of ignition is so very much greater than the rate of diffusion of oxygen through an envelope of inert products of combustion, that anything that can be done to disturb the envelope accompanying a particle of powdered coal will aid the natural diffusion of oxygen and accelerate combustion. Successful reduction of furnace volume will greatly widen the field of powdered coal.

Experience with large furnaces has, in general, been good, most if not all of the difficulties being due to lack of information on the part of designers working in a field new to them. There is a strong tendency among power-plant engineers to use water-cooled furnace walls to eliminate troubles with refractories. Such lowering of average furnace temperature as there may be does not go far enough to interfere seriously with the completeness of combustion.

There is a growing interest in preheating air for combustion, which would not be advisable with air-cooled walls.

NEED FOR STANDARD RATING OF OVERALL EFFICIENCIES

The best fuel-burning practice in large power plants is now so highly developed that but little more in thermal efficiency can be expected in this direction. This has been brought about by a careful study of all the causes of loss of heat. As each loss is reduced or eliminated, rising efficiency follows as a matter of course. There is an increasing tendency to apply the same research point of view and the same methods in other fuel-burning arts. This is noticeable in railway fuel practice, steel furnaces, and the ceramic industries, where notable savings in fuel have been made. The renewed interest in fuel saving on the railroads made a saving in 1924 of nearly $25,000,000 over the practice of the previous year. In improving furnace practice in connection with boilers the art had the great advantage of having a standard method of testing the overall efficiency of the heat generator and heat absorber, which made an allocation of losses fairly easy.

In many other fuel-using arts such standards remain to be developed. To obtain a heat balance on a brick kiln is quite a different matter from obtaining one on a steam boiler. It is encouraging to note that there is an attempt to develop a standard method of testing gas- and coke-making equipment.

There has been a sustained interest in the broad subject of processing fuels, although the year has seen no installations of commercial low-temperature plants in this country. There has been a more general appreciation of the fact that along with the recoverable by-products there are many unanswered questions regarding their quality and value. This makes it difficult to accurately estimate the probable returns from any process.

THE NEW FIELD OF SYNTHESIS

A book on The Conversion of Coal into Oils by Fischer and Lessing places before English readers the basic work of many investigators. A supply of oil for fuel is earnestly desired by every important country lacking a natural supply of petroleum. We shall in turn be increasingly interested as the demand for motor fuel crowds our natural supply. Several ways of obtaining oil from coal are (1) by extraction by solvents; (2) by the production of primary tar by low-temperature distillation; (3) by adding hydrogen to coal; (4) by combining gases produced from coal; and (5) hydrocarbons from carbides.

Solvents may extract from coal about one-half of one per cent of liquid fuels, too small an amount to be of commercial promise.

From primary tar produced by low-temperature distillation about 4.4 per cent of light motor fuels of various sorts may be obtained and a further 5 per cent applicable partly as lubricants and partly as fuel oil.

By subjecting powdered coal held in oil to high pressures and temperature with agitation in an atmosphere of hydrogen, laboratory experiments show that 10 to 45 per cent of the coal has become soluble. After removing the carrying oil there remains a pitch or asphalt-like product possibly capable of further hydrogenation and partial reduction to motor fuel. It is reported that the German and Prussian governments are aiding the installation of a plant to treat 200,000 tons per year, which, if true, will show the commercial practicability of this process.

By chemically combining water, gas and hydrogen, liquid fuels can be made. The gases can be obtained by burning coal, and the conditions necessary to combination are known. In the production of methanol to replace wood alcohol the process has been commercially developed. It is estimated that one ton of coke should make 350 gallons of methyl alcohol, which, with engine modifications, could be used for motor fuel.

By other variations of the idea, Fischer and his associates have produced on a laboratory scale a mixture of liquid fuels which they term "synthol," wherein about one-third of the water gas is converted into products having a distillation range suitable for motor fuel. These results are so promising as to shift the major accent in investigation from the field of low-temperature distillation to the new field of synthesis of gases.

THE NEW PHASES OF FUSIBILITY AND CLINKER FORMATION

The combustion of coal in large quantities meets a limitation imposed by furnace refractories before the combustion is as efficient as present practice can readily produce. To reduce the excess air to something very close to the theoretical limit and have practically no combustible in the flue gas is entirely possible in many of our best installations. However, a larger excess of air is maintained under operating conditions because firebrick will not stand the conditions. The point of dollar efficiency is reached before technical efficiency is attained. It has been assumed that it was the high temperature produced by efficient combustion that made brick fail, but a careful study of the problem made it evident that we were unable to tell the ceramic engineer just what were all the conditions which his product was asked to endure. Temperature alone is by no means the only important factor. Other elements of the problem are the rate of temperature changes, the character and velocity of furnace gases, the reaction between brick and the molten ash particles, the mechanical stresses and distribution of stress due to load and to expansion forces. With the problem more definitely stated it can reasonably be expected that the ceramic engineer can push back this limitation by producing a more suitable refractory. A study along this line was made possible by group action headed by Mr. C. F. Hirshfeld, now chairman of a committee of the Society interested in this project.

When the ash in coal fuses into clinkers in the furnace, limitation of both capacity and efficiency of combustion are apt to follow. The fusibility of ash as determined by laboratory methods is being determined to an increasing extent, but it is not entirely clear as to what relation exists between such determination and the limitations from clinker formation as actually found in practice. To correlate fusing temperature and clinker troubles in the furnace, a study is made possible by a group headed by Mr. E. B. Ricketts, representing a committee of the A.S.T.M.

The study of these two fuel problems made possible by group action for the benefit of all is a commendable tendency at the present time.

An International Coal Classification Needed

An increasing need is felt for a classification of coal that will apply universally. Different countries have different limits for the several kinds of coal, different methods of analysis and sampling. When one talks of coal on an international basis there is much confusion because names are interpreted differently in different places. There has been proposed by Mr. C. I. Seyler of Great Britain a scheme that seems to approach the desired end in international classification of coal.

O. P. HOOD, *Chairman.*

Progress in Petroleum Engineering

Contributed by the Petroleum Division

Executive Committee: W. R. Eckart, *Chairman*, H. R. Pierce, *Vice-Chairman*, Carl F. Braun, T. H. Kerr, and Walter Samans

SINCE the beginning of the petroleum industry in this country, dating back about sixty-six years, its progress, from force of circumstances, has been largely of an empirical character. Drilling and pumping methods were adapted from those used for water, as were the methods for the distillation of petroleum adapted from those previously developed for the production of illuminating and lubricating oils from coal.

Scientific progress has been handicapped more or less for a number of reasons. In the first place, petroleum itself is an extremely complex mixture, made up of various proportions of hydrocarbons of different series and containing some impurities, so that the petroleum oils to be handled are seldom of the same composition. The physical properties of these mixtures, upon which so much of the scientific work depends, vary in magnitude with the nature of the mixture and are therefore not known with any degree of exactness, without special determination in each case. Again, where such complex mixtures have to be considered, the application of the physical laws concerned to the solution of the problems becomes extremely difficult and involved. Small-scale laboratory experiments when reproduced on an operating scale do not generally give results of the same order, which is largely due to the lack of dimensional similarity in all of the factors involved. Research work requiring full-scale equipment can only be carried out in the field, and in most cases requires a large outlay of capital. Owing to this large financial risk, companies are not disposed to take chances upon unproven methods or equipment. Or, in the case where manufacturers have developed special equipment, the introduction of this into practice is often delayed or prevented, as even the cost of installation and loss of operating time may be considerable. Further, there remain the general dislike and often passive resistance on the part of many operators to the use of apparatus with which they are unfamiliar. Often there is a lack of incentive, a willingness to let "well enough" alone until such time as economic conditions provide a situation demanding more efficient equipment and methods of operation.

The past year will stand out prominently in the history of progress in the petroleum industry, not necessarily due to any particular outstanding development, but rather to the most thorough and painstaking survey of the industry, in all its branches, made from within. This was accomplished as a result of the creation, by the President of the United States, of the Federal Oil Conservation Board, for the purpose of making a study of the nation's future supply of petroleum.

This survey has been made by a committee of the American Petroleum Institute[1] in order to coöperate with the Federal Oil Conservation Board, which at the time of writing has not yet made its report.

As stated by the committee,

> The survey has been country-wide, engaging not only the attention of a great number of operators, experts and scientists within the industry, with personal and first-hand knowledge of conditions in the numerous oil-producing regions of the nation, but also of foremost experts in other matters which have a direct bearing upon the future of oil.

[1] American Petroleum—Supply and Demand. A Report of the American Petroleum Institute, McGraw-Hill Book Co., 1925.

This comprehensive, authoritative, and up-to-date report is the outstanding publication in the field of petroleum as regards the problems of supply and demand. Material from this source has therefore been freely quoted or abstracted in the preparation of this present review of recent progress in the industry.

The Need for Coöperative Research

In addition to the facts and figures presented and the knowledge gained therefrom, one of the most important things emphasized by the A.P.I. report is the recognition of the need of *coöperative research* within the industry itself. While the statement in the report bears directly upon oil production, it is equally true as to all other branches of the petroleum industry. The report points out:

> There are a number of problems relating to the technical phase of oil production which we believe possible of solution, but on which so little scientific and experimental work has been done that they remain a fruitful field for the prosecution of research. To date oil companies have not been able to carry on as much of this type of work as is desirable, so that those experiments which have been made have to a large extent been performed by governmental agencies. Due to the lack of funds, however, these agencies have not been able to prosecute this work with broad enough scope to keep pace with the development of the industry. We find oil companies are showing an increased tendency to enter this field of endeavor, and we believe that within a few years practically all companies will have their own research departments. When this develops there will be an enormous duplication of effort in solving those problems which embrace basic scientific principles that are purely mathematical, physical, and chemical. It is therefore highly desirable that *some form of coöperation* be immediately established among oil companies to make a study of these basic principles, in their application to the practical problems of the industry.

Many refineries have been in the past and at present are conducting research work, resulting often, as stated, in duplication of effort. During the past year there has been much evidence of less reluctance to exchange, by publication, information so gained, resulting in a wider and growing spirit of coöperation and adding materially to the art of refining. Reluctance, however, on the part of companies who have invested large sums toward the furtherance of research is only natural, and it is only right that they should benefit by any financial rewards that may result from their investment and efforts. At the same time, where duplication is incurred, coöperation would result in large savings, both in money and effort; and would enable a much more extensive field of research to be covered in the same time, resulting in more rapid progress in the industry as a whole.

In addition to this coöperation between oil companies there should also be developed better coöperation between manufacturers of equipment and its users. Mr. H. C. Parmelee[1] has pointed out in detail the reasons and causes which, in the chemical industry, underlie the lack of such coöperation; and which he classes as one of the wastes of industry. Manufacturers of equipment have in many cases spent large sums in experimental research during the development of their equipment, and so likewise have many of the oil companies in the development of their processes and methods of operation. Highly competitive conditions make each party unwilling to disclose to the other full and necessary information.

[1] H. C. Parmelee, Relation of the Equipment Manufacturer to the Chemical Industry, *Chem. & Met. Engrg.*, June, 1925; also editorial in same issue.

Full coöperation can only be obtained when business ethics have reached the point where confidential information will be scrupulously guarded by both parties and not used in any way detrimental to the interests of those who furnished it.

In many cases much of the secrecy maintained is needless and unwarranted. There is consequently economic loss and a slowing up of progress.

TRENDS IN THE PRODUCTION OF PETROLEUM

New Prospecting Methods. Scientific progress is being made rapidly in the methods[1] developed and introduced for the discovery of new oil fields. This has been brought about by the employment in the last few years of more scientifically trained men in this branch of the industry.

Core drilling by the rotary method or by the diamond drill has been responsible for the location of new fields in Oklahoma, Kansas, and California. Improvements have been made within the past year in the taking of cores from wells, but as yet no satisfactory method has been devised to obtain an oriented core. While a determination of the amount of dip is of value, a known orientation would be of increased value.

Paleontologic examination of well cuttings will open up new sources of oil, and has already had its influence in California and in the Mid-Continent and Gulf States.

Research work is being done in correlating various underground waters, by identification through chemical and physical examination.

More accurate and complete records are being made of all wells drilled.

The most notable progress in the application of new methods has been through the use of the seismograph and torsion balance, which led to the discovery of three salt domes in the Texas Gulf Coast Region in 1924. From the apparent success attained it is anticipated that these methods will completely supersede the older methods.

Brief descriptions of these methods as given by the committee of the American Petroleum Institute are as follows:

> The seismic method is based upon the fact that mechanical waves set up in the earth by some shock, most suitably an explosion of dynamite, are transmitted at greatly different velocities in strata of different elasticity. In consequence, very sensitive but portable seismographs, placed at some distance from an explosion, will register the earth waves successively as they arrive, transmitted along various beds of different elasticity. The time required for their transmission, which can be accurately measured on a moving film, indicates the nature of such beds, whether clay, loose sand, sandstone, limestone, anhydrite, or rock salt; and also the approximate depth at which such strata lie, down to a depth of 6000 ft. or more.

Gravitational exploration, in which the torsion balance is used, is

> .... based upon the fact that minor deviations from the earth's gravitational attraction are caused by local differences in the specific gravity of masses underlying the surface. The attraction at one station will be greater if the average density of the upper horizons of the columns of rocks underlying it, is greater than another station. These anomalies are extremely small and it requires extraordinarily sensitive instruments to detect them reliably.

These methods serve to locate underground structures, which may contain oil, but do not determine the presence of oil directly. However, subsurface structure and oil are so closely related that a knowledge of the structure is of great assistance. The committee expresses the hope that

> With the thoughts of the various research departments turned toward mechanical means of locating underground structures, it is not beyond the realm of possibility that scientific apparatus will be perfected which will indicate the actual presence of oil.

Aerial Photographic Surveying. The U. S. Geological Survey has made use, in the Elk Hills Naval Oil Reserves, of aerial photographic surveying and mapping[2] to assist in obtaining clues to petroleum deposits from the topography of inaccessible areas.

New Methods of Recovering. Lack of progress in technical work toward improved methods of recovery[3] has been noted, as compared with those made in petroleum geology, refining methods, and casing-head gasoline manufacturing processes. However, the committee on supply of the American Petroleum Institute in its study of the situation states that[1]

> It is the general opinion of executives, engineers, and geologists throughout the country that there will still remain in the ground, after all flowing and pumping have ceased, more than twenty-six billion barrels of additional oil. With improved methods of recovery such as mining, flooding, the restoration of pressure, and other scientific methods yet to be devised, we believe a large proportion of this oil can be recovered from the present producing fields. The production of this oil, because of the nature of its occurrence, must necessarily be spread over a long period of years.
>
> The quantity of oil to be recovered by improved methods now in use in certain parts of the country, apparently will be large, greatly exceeding in some cases the amount of oil recovered through many years of flowing and pumping.

Four of the methods referred to are in successful use at the present time: namely, flooding, air or gas pressure, unwatering, and mining; the first three in this country and the fourth in France. They can be briefly described as follows:

Flooding. In the flooding method the most common arrangement is to pump water into a central water well around which are drilled oil wells in circular arrangement into which the oil is flushed. This plan is not considered by many as either efficient or economical, and variations of it are being put into operation.

Compressed-Air or Gas Method. In this method gas or air is forced into certain wells by means of compressors and the oil is forced to other wells and pumped out. It is reported[2] to have been successful in 80 per cent of the places used, including 4000 wells on 100 properties.

Unwatering Method. In one development this method was followed by drilling to the bottom of the sand; then, using a large working barrel and by pumping continuously, the water was exhausted and some gas obtained. By the use of vacuum pumps and compressors the process was accelerated and gasoline produced. Entrance of new water through old holes is prevented by plugging them.

Mining Method. In this method as used in France, 43 per cent of the original oil is recovered by natural drainage into tunnels driven into the oil sands, and it is proposed later to wash and retort the saturated sand remaining, by which an additional 32 per cent can be obtained.

In this country mining methods are necessary which do not involve tunneling into the sand, as the gas remaining in the sand makes the work both dangerous and expensive. It is proposed to sink shafts to a short distance either above or below the oil sands. Galleries will be extended from these shafts parallel to the sand and from the galleries numerous small holes will be drilled into the sand and tubed. Oil and gas under control will be admitted through them into the galleries. To increase the amount of recovery over that which would drain naturally, it is proposed to force air or superheated steam into the sand.

The present status of the known improved methods of oil recovery indicates that these methods should not be applied until flowing and pumping have ceased.

Drilling, Pumping, and Surfacing Equipment. The American Petroleum Institute[3] during the past year has had committees working on specifications looking forward to the simplification, standardization, and improvement of oil-field drilling, pumping, and surface equipment.[4] In so doing it has been aimed to avoid any possible interference with individual initiative or with the progress of invention. Specifications have been completed or are being made for:

Steel and Iron Pipe for Oil-Country Tubular Goods[5]

Cable-Drilling Tool Joints[6]

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[1] American Petroleum—Supply and Demand. A Report to the American Petroleum Inst., McGraw-Hill, 1925, p. 66.

[2] Chas. E. Kern, *Oil & Gas Journal*, July 16, 1925, p. 37.

[3] John M. Lovejoy, Am. Inst. Mining Engrs., Petroleum Division.

[1] American Petroleum—Supply and Demand. A Report to A.P.I., p. 9, McGraw-Hill Book Co., 1925.

[2] J. O. Lewis, Bulletin No. 148, U. S. Bureau of Mines.

[3] Bulletin S-1, American Petroleum Inst., Div. of Standardization: Plan of Organization of Special Committees and Methods of Procedure for Development of Standards, Apr., 1925.

[4] Report on Standardization of Oil Drilling Equipment, 5th Annual Meeting A.P.I., Dec., 1924.

Group Session on Improvements in Oil Drilling and Production Methods and Equipment, 5th Annual Meeting, A.P.I., Dec., 1924.

[5] Bulletin No. 5, A.P.I., 1924.

[6] Bulletin No. 3, A.P.I., 1924.

Standard Rigs and Derricks
Rotary Drilling Equipment
Rig Irons
Pumping Equipment and Engines
Wire Rope and Manila Cordage
Belting
Oil-Field Boilers
Steel Storage and Production Tanks.

Surface-equipment machinery and methods[1] used for pumping wells have not been greatly developed and in many cases are practically the same as those used 25 years ago. It is also pointed out that

> Development and operation in the older oil fields tended to standardize pumping methods and to diversify pumping equipment. The present tendency is toward standardization of equipment used for similar purposes, and diversity of pumping methods to meet the conditions at individual wells.

Mr. John A. Zublin[2] similarly notes that:

> There has never been much change in the construction of pumping equipment. When oil was discovered and the necessity to pump it out of the wells appeared, it was logical to use the same type of pump which had been successfully applied to the pumping of water wells. This simple pumping machinery has been in use ever since, and while pumping wells steadily increased in depth, the same type of plunger seemed to satisfy pumping conditions.
>
> A large number of patents referring to oil-well pumps have been granted in recent years, many of them show improvements in pumping methods, but very few of the numerous inventors have made a serious effort to carry their new ideas through a number of extensive tests and experiments into practice.

When the deep wells in Los Angeles basin ceased flowing, it was found that the ordinary pumping installations were not adequate to lift the oil. It was therefore urgently necessary to find means to handle the situation. After experiments and tests covering two years, and after considering all other possible methods, such as compressed air or gas, hydraulic or electric power transmission, the final conclusion was that the only feasible one was to use

> . . . . mechanical means, the pumping machinery in the derrick, the power transmitted by mechanical connections, rods, cables, etc. to the pump submerged in the fluid.

An analysis and investigation of this method in detail showed that on the surface no improvements were necessary in the power plant or method of power transmission. Attention, however, is called to the fact that

> . . . . the motion of the walking beam imparted to the sucker rod is not ideal. The elasticity of long strings of rods in deep holes combined with the abrupt reversing motion from down stroke to up stroke of the walking beam endangers the rods; but several devices, mostly connected with crank and pitman, effectively overcome this defect. *A simple and practical apparatus which will reverse from the down stroke to the up stroke gradually and without violence is very desirable, and might do good work in many fields.*

This difficulty due to the elasticity of long pump rods was pointed out in the transactions of The American Society of Mechanical Engineers in 1882[3] in connection with tests of pumping equipment on the Comstock lode, undertaken as a result of the breaking of the long, heavy rods. To quote:

> Some very important results of the elasticity of long pump rods are clearly set forth in one case: A rod at a point 1800 ft. below the surface showed a positive pause, while the engine driving it was nearly at its point of maximum motion, and pumps attached to the rod may have, and do have, strokes in excess of or deficient to *the stroke of the engine driving same*, and to an *important extent*. Hence, I think, it can be definitely stated that any consideration of motion of pumps, or discharge capacity, driven by a long line of pump rods, based upon the motion or stroke of a surface engine alone, will in no way be even approximate unless the elasticity and effects of counterbalancing by balance bobs on that elasticity is also considered.

Further, Mr. Zublin states that if desired an increase could be made in the number of revolutions and length of stroke, if steps are taken to have the plunger willingly follow the full length of stroke.

With longer strokes an adoption of rectilinear motion for the connection between beam and rods is desirable. Also more attention to obtaining a correct counterbalance will eliminate a source of power loss and troubles.

In the hole no improvements are proposed for the sucker rods, tubing, barrel, or standing valve. Changes are suggested (*a*) in the plunger design to reduce leakage under high pressures, so as to handle sand and impurities in such a way as to reduce the detrimental effects as much as possible, (*b*) in the use of higher-grade steels to prolong the life of the plungers, (*c*) provision for securing better drop of plunger and full length of stroke, (*d*) better valve arrangements to obviate difficulties due to gas, and (*e*) the use of an effectively designed gas anchor with standardized openings acting as a trap and separator to keep as much free gas outside of the pump as possible.

Mr. R. G. Strong[1] states that during the past year considerable attention has been paid to the matter of counterbalance jacks, long-stroke attachments, and special motor-driven gear reduction. He further calls attention to the fact that tests conducted on standard beam pumps have shown that they are not as efficient as they should be, especially when electric motors are used for power.

Cleaning of Wells. In the Mid-Continent fields, according to Mr. Hollis P. Porter,[2] the outstanding new process being developed is the use of compressed air for cleaning out wells. It has proven to be successful and economical, but there remains much to be learned about the principles involved.

Cementing of Wells. Mr. F. F. Hill[3] has presented an outline of the development of the use of cement for shutting off water in California wells, with data relating to some of the recent accomplishments in this line.

Mr. Hollis P. Porter suggests[4] in this connection a line of research on

> . . . . cements for cementing oil wells, with a view to determine what kind of cement is best for shutting off water and to learn if there are any special kinds of cement accelerators which would cause cement in a well to set quickly without deterioration.

THE LEADING PROBLEMS OF STORAGE

Evaporation Losses. Evaporation losses from crude oil and petroleum products in field storage and during transportation to the refinery have been shown to be so large, amounting to about 4 or 5 per cent, as to demand serious consideration from the industry. The economic loss is due to the reduction both in volume and gravity. Marked savings have been effected by making the tanks vapor-tight[5] with vacuum and pressure relief valves and vapor-tight hatches; and by floating tank decks, etc. These measures are sometimes supplemented by such devices as water-cooling systems, insulation, and light-colored paints.

The Standard Oil Company of Indiana have applied the use of breather balloons[6] to gasoline storage tanks. It is estimated that 50,000,000 gallons of gasoline could be saved annually by their general application. These balloons eliminate the breathing loss which amounts to over 3 per cent a year. This is due to the daily change in temperature, the higher temperature during the day expanding the air above the gasoline and vaporizing enough gasoline to expel through the vent pipe several thousand cubic feet of rich gasoline-saturated air from a modern storage tank holding around three million gallons. At night the vapor space cools and a supply of fresh air is drawn in, which in turn becomes saturated with gasoline and is breathed out the next day. The breather balloons are constructed from a specially developed gasoline-proof fabric, and are housed in galvanized buildings. The balloons are connected to the vapor space of the storage tanks and the gasoline-

[1] H. C. George, Surface Machinery and Methods for Oil-Well Pumping, Bulletin 224, Bureau of Mines, 1925.

[2] John A. Zublin, Pumping Deep Wells in California, Annual Meeting, A.P.I., 1924.

[3] William Roberts Eckart, Chronograph for Engineering Purposes, etc. Trans. A.S.M.E., vol. 3, 1882, p. 187.

[1] Private communication, Aug. 27, 1925.

[2] Private communication, Sept. 5, 1925.

[3] F. F. Hill, Cementing Deep Wells, Annual Meeting A.P.I., Dec., 1924.

[4] Private communication, Sept. 5, 1925.

[5] Ludwig Schmidt, Effect of Color on Evaporation, *Oil & Gas Journal*, Apr. 16, 1925, p. 58.
C. O. Willson, Nat. Petroleum Assn. Meeting reviewed, *Oil & Gas Journal*.
W. T. Anderson, Progress in Refining, editorial in *Oil & Gas Journal*, Feb. 26, 1925.

[6] Wilson, Atwell, Brown, and Chenicek, American Chemical Society, Los Angeles Meeting, Aug., 1925.

saturated air is allowed to expand and contract into the balloons with the changes in temperature, without loss. The breather bag is weighted to keep the pressure on the tank substantially balanced at all times, preventing losses through small openings which are hard to eliminate entirely. Automatic release and intake valves provide for pumping to and from tank or for exceptionally large "breaths" beyond the capacity of the balloon.

Fire Hazard. The serious consequences, both economic and other, due to the fire loss from oil in storage have led to considerable study and investigation.[1]

A committee appointed by the American Petroleum Institute to report on The Spacing Necessary in Location of Tanks made the following recommendations:

All-steel tanks of air-tight construction

Separate classification of tanks for storage of crude and those for gasoline, kerosene, and fuel oils

The space between tanks in the case of refined oils should equal the diameter of the tanks, and for crude oils should be double the diameter. Adequate protection through the use of chemicals should reduce this spacing one-half.

Fire walls in case of crude should provide capacity equal to that of the tank and not 150 per cent as now required. Top of fire wall should be located not closer than the diameter of the tank. Fire walls not necessary in case of light oils. In the case of crude-oil storage, fire walls should be constructed with coping so as to make it more difficult for crude to go over the wall.

TRANSPORTATION

Pipe Lines. Few new pipe lines[2] were built in the first half of 1925. The largest were those of the Standard Oil of Louisiana, a 10-in. line, 100 miles in length from the Smackover field in Arkansas to Grand Lake on the Mississippi River, and the Humble Company's Big Lake 8-in. line, 200 miles long. Most of the work has been in gathering lines, extensions to existing lines, and loop lines.

Some improvement has been made by replacing inefficient heaters at the pump stations with those of more modern and effective types. More attention has been paid to securing better insulation of the lines.

One company handling a 12 deg. A.P.I. crude has improved conditions very materially increasing their pipe-line capacity, reducing necessary boiler capacity and fuel consumption, lowering the pipe-line working pressure, etc. by the installation of new heaters and of rotary pumps between the storage tanks and the suction heaters of the main direct-acting pumps. The heaters were thus put under sufficient pressure to eliminate pumping troubles principally due to the oil vapors given off, which limited the operating temperatures.

MARINE TRANSPORTATION

Means to prevent the pollution of harbor waters by fuel oil pumped overboard with water from tankers and vessels using oil fuel are being given serious consideration.

The serious damage caused by the destruction of fish, together with the material increase in the fire hazard to harbor property, led the Government to prohibit the discharge of oil or water containing oil into the coastal waters of the United States. Oil separators[3] have been developed as one means to eliminate this obnoxious and dangerous practice.

REFINING AND MANUFACTURING

Increase of efficiency[4] rather than increase of capacity has been the aim of the refiners in the past year. Additional and larger cracking plants have been installed, and many improvements have been made in skimming plants which have increased the output of gasoline. Installations of towers and other equipment to secure better fractionation have been made. While the refining capacity of the plants has not been increased, the amount of crude handled has.

Cracking Process. The cracking process[1] which has taken a leading part in the conservation of petroleum, through the greater production of refined oil, continues the most important development in refining.[2] Improvements both in methods and details continue to be made.

The tendency toward larger units[3] remains, as well as the more intensive use of the fuels available for charging stock, that is, the cracking of kerosene and low-viscosity fuel oil.

In the "Refining Number" of the *Oil & Gas Journal*[4] a survey of the cracking process is presented from different aspects by various authors, together with descriptions of some of the processes.[5]

Egloff and Morrell[6] point out the value of the gases produced during the cracking process for fuel purposes, and also note that considerable progress is being made in the production of alcohol and other chemical derivatives.

California refineries have installed 51 cracking stills, 40 of which are of the high-pressure liquid-phase type, while 11 are experimental in the running of California crudes and are of the semi-liquid and semi-vapor low-pressure types.

Among other important new installations the Atlantic Refining Company[7] have six 1000-bbl. cross-cracking stills in operation at Franklin and six 2000-bbl. stills practically completed at Philadelphia.

Pipe Stills. Progress is being made by the more general installation of pipe stills in refinery practice in place of the conventional shell still, giving increased yields with reduced cost of fuel and maintenance.[8]

The Atlantic Refining Company[9] have under construction three 5000-bbl. pipe stills with Foster furnaces and tube units.

Centrifugal Pumps for Oil. Centrifugal pumps are used in various plants for pumping oil. During the past year Prof. R. L. Daugherty[10] conducted a series of tests with oils of different viscosities and vapor pressures under different operating conditions. These tests are being extended this year.

A centrifugal pump especially designed for handling hot oils has been developed for use in one of the cracking processes.

Fractionation. More intensive applications of fractionation to the products of distillation have been attended by very marked operating success. As a result there has been not only "empirical" development of fractionating towers, both of the packed and plate type, but there has been a wider study of the principles of fractionation and their application to the design of efficient equipment.[11] Most of these studies have, however, for simplicity dealt

[1] H. H. Hall, Oil-Tank Fire Boilovers, MECHANICAL ENGINEERING, July, 1925, p. 540.
H. H. Hall, Fire Banks for Oil Storage, Proc. A.S.C.E., May, 1925, p. 721.

[2] Few New Pipe Lines Built This Year, *Oil & Gas Journal*, July 30, 1925, p. 80.

[3] W. J. Barnes, An Oil Separator for Purifying Ballast Water Discharged from Ship Fuel-Oil Tanks, MECHANICAL ENGINEERING, Aug., 1925, p. 645.

[4] C. O. Willson, Refinery Operation, *Oil & Gas Journal*, Apr. 30, 1925, p. 60.

[1] C. M. Johnson, The Manufacture of Gasoline by the Cracking of Heavier Oils, MECHANICAL ENGINEERING, Dec., 1924, p. 879.

[2] W. T. Anderson, Editorial on Progress in Refining, *Oil & Gas Journal*, Feb. 26, 1925.

[3] L. M. Fanning, Larger Units Being Installed for Cracking Gasoline this Year, *Oil & Gas Journal*, June 18, 1925, p. 82.

[4] *Oil & Gas Journal*, Feb. 26, 1925.

[5] C. E. Bowles, Cracking Capacity Compared by Area, p. 104.
Gustav Egloff, Some Economic Aspects of Cracking, p. 106.
L. A. Tarbox, Cracking Process for Small Refinery, p. 92.
Jenkins cracking process described, p. 100.
Cross cracking process described, p. 109.
F. A. Howard, Continuous Type of Pressure Process, *Oil & Gas Journal*, Mar. 5, 1925, p. 109.

[6] G. Egloff and J. C. Morrell, Gas Formation in the Cracking Process, *Ind. & Eng. Chem.*, Jan., 1925. p. 32.

[7] Walter Samans, private communication, Sept. 5, 1925.

[8] John Primrose, Increasing Usefulness of Pipe Stills, *Oil & Gas Journal*, Feb. 26, 1925, p. 112.

[9] Walter Samans, private communication, Sept. 5, 1925.

[10] R. L. Daugherty, Investigation of the Performance of Centrifugal Pumps when Pumping Oils. A report to The Goulds Mfg. Co., 1925.

[11] E. V. Murphree, Rectifying Column Calculations, *Ind. & Eng. Chem.*, July, 1925, p. 747.
W. L. McCabe and E. W. Thiele, Graphical Design of Fractionating Columns, *Ind. & Eng. Chem.*, June, 1925, p. 605.
E. V. Murphree, Graphical Rectifying Column Calculations, *Ind. & Eng. Chem.*, Sept., 1925, p. 960.
I. B. Chittenden, Fractionation and Tower Design, *Oil & Gas Journal*, Feb. 26, 1925.
B. T. Brooks, Refiners Interest in Research Work, *Oil & Gas Journal*, Feb. 26, 1925.
G. W. Reid, Multiple Streams from Bubble-Type Tower, *Refiner and National Gasoline Manufacturer*, Dec., 1924.

with binary mixtures and not with the more complex mixtures which have to be handled in petroleum fractionation. Extensive installation of such equipment has resulted in simplification of the processes, in reduction of operating costs, in materially increased production, and in improved quality of products.

Treating Processes. Purification of the various distilled products of crude oil, such as gasoline, naphtha, kerosene, lubricating oils, and paraffin wax by chemical treatment or filtering or both, is essential in most cases before they can be marketed. The various "refining" or "treating" processes in use at present for each class of product are described and discussed in recent papers.[1] Improvements due to research have resulted in superior products at reduced cost.[2]

Commercial developments[3] of the recently introduced process using calcium or sodium hypochlorite solution have shown, as applied to the treatment of natural gasoline, a marked superiority over older methods as to economy, ease of operation, and uniformity in production of a "sweet" and non-corrosive product.

Advance has also been made in contact filtering processes. These methods have employed special clays or very fine fullers' earth. California bentonite or montmorillonite has shown exceedingly high refining capacity, as much as sixteen times that of ordinary fullers' earth.[4]

In the treatment of pressure distillate, an important development is the Gray process[5] in which the distillate in the vapor phase is refined by means of fullers' earth. It appears to have many advantages.

A notable example of the purification of natural gas is also recorded.[6] In October, 1924, a well was brought in,[7] in Canada, producing 400 bbl. per day of 73 deg. B. naphtha together with a flow of gas of twenty-one million cubic feet per day. The gas is heavily impregnated with sulphur. Owing to the detrimental effects of the sulphur fumes, experimental work on a large scale was successfully conducted and the gas is purified by absorbing the hydrogen sulphide in a soda ash solution, after which the impregnated soda-ash solution is passed into "actifiers" through which air is forced countercurrent to the solution. The air separates the hydrogen sulphide from the solution and carries it off through the stack. The purification of the gas also reduces the corrosion of pipe lines, distributing systems, meters, and incidental equipment.

Natural-Gasoline Processes. The process for the extraction of gasoline from natural gas by absorption in oil under pressure or by charcoal continue to be improved by the design and installation of more efficient absorbing, distillation, condensation, heat-transfer, and fractionation equipment.[8] The recently introduced process of "stabilizing" natural gasoline is scientific fractional distillation.[9]

The most complete and authoritative recent work on the subject is that of Mr. G. A. Burrell,[10] which covers all of the most important developments of the industry such as history, the theoretical and practical design of plant equipment for the different processes, testing methods, statistical data, etc.

Manufacturers of equipment have been giving extensive study to this branch of the industry, not only as regards the design of individual pieces of equipment, but also in the production of complete plants of high efficiency of extraction. The unit processes involved have been and are still the subject of much research,[1] as they form part of the fundamental or basic processes of all the chemical industries. The scientific principles are the same in every case, so that they are of general application. However, in the petroleum industry their application is not always simple. Owing to the complexity of the mixture and the nature of the fluid, various operating difficulties present themselves which must also be overcome. The general statement may be made that absorbers, stills or evaporators, fractionators, and especially heat exchangers and condensers for all purposes, are now highly superior to and more scientifically designed than those previously used in the industry.

Experimental work on a considerable scale with silica-gel[2] as the absorbing medium is being conducted at one of the plants in California.

MATERIALS OF CONSTRUCTION

Petroleum equipment in the refinery and elsewhere is subjected in many cases to extremely high temperatures and pressures, to excessive expansion and contraction changes, and to corrosive action due to impurities carried into the system with the crude, as well as to the chemicals used to purify the product and the water used for cooling purposes. These corrosion troubles are responsible for large financial losses due to extra cost of maintenance, loss of operating time, and the extra cost of stand-by equipment.

To combat these severe operating conditions much research work[3] continues to be necessary with a view to provide materials suitable to withstand the corrosive elements, or to provide processes or methods which will eliminate or reduce the corrosive elements themselves. Materials, suitable for these conditions, as well as to satisfy the high-temperature requirements, and which can be satisfactorily fabricated, are urgently needed.

LUBRICATING OILS

Conservation of lubricating oils through the elimination of the enormous waste which now takes place through the draining and discarding of used automobile crankcase oil continues to be the subject of much study.[4] Means of determining the proper time to change the crank oil and the reclamation of the used oil are in the development stage.

A standard classification of lubricating oils according to their lubricating properties is to be desired; and to this end some positive

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[1] A. P. Bjerregaard, Modern Processes of Treating Oil, *Oil & Gas Journal*, Mar. 5, 1925, p. 96.
C. K. Francis, Treating Refinery Products Important, *Oil & Gas Journal*, Mar. 5, 1925, p. 107.

[2] W. T. Anderson, Editorial on Progress in Refining, *Oil & Gas Journal*, Feb. 26, 1925, p. 64.

[3] W. S. Hiatt, Treating Methods used in "Sweetening" of Natural Gasoline, Proc. Assn. of Natural Gasoline Manufacturers, Apr., 1925, p. 40.

[4] *Chem. & Met. Engrg.*, Jan. 19, 1925, p. 99.

[5] D. M. Liddell, Vapor Phase Refining of Gasoline, *Chem. & Met. Engrg.*, Dec. 22, 1924, p. 975.

[6] Natural Gas Purification Accomplished, *Refiner & Natural Gasoline Manufacturer*, Dec., 1924.

[7] Chester A. Bloom, *Oil & Gas Journal*, July 23, 1925, p. 21.

[8] F. P. Peterson, Equipment of Natural Gasoline Plants, *Oil & Gas Journal*, Feb. 26, 1925, p. 201.

[9] B. T. Brooks, Refiners Interest in Research Work, *Oil & Gas Journal*, Feb. 26, 1925.

[10] G. A. Burrell, The Recovery of Gasoline from Natural Gas, Monograph No. 20, Am. Chem. Soc., The Chemical Catalog Co., 1925.
A. P. Bjerregaard, Distribution of Sulfur in the Fractions Derived from Crude Petroleum, *Ind. & Eng. Chem.*, Feb., 1925, p. 142.

[1] Absorption Symposium, *Industrial & Engineering Chemistry*, Dec., 1924.
W. K. Lewis and W. G. Whitman, Principles of Absorption, p. 1215.
H. G. Becker, Mechanism of Absorption of Moderately Soluble Gases in Water, p. 1220.
Haslam, Hershey, and Kean, Effect of Gas Velocity on Absorption, p. 1224.
P. G. Ledig, Absorption of Carbon Dioxide and Ammonia from Gas Bubbles, p. 1231.
W. G. Whitman and D. S. Davis, Comparative Absorption Rates of Various Gases, p. 1233.
F. W. Sperr, Jr., Absorption of Hydrogen Sulfide, p. 1237.
H. C. Weber, Quantitative Analysis of Mists and Fogs, Especially Acid Mists, p. 1237.

[2] H. N. Holmes and J. A. Anderson, A New Type of Silica-Gel, *Ind. & Eng. Chem.*, Mar., 1925, p. 280.

[3] F. W. L. Tydeman, Corrosive Troubles in Refining, Their Cause and Correction, *Oil & Gas Journal*, Mar. 5, 1925, p. 107.
R. Van A. Mills, Protection of Oil and Gas Field Equipment against Corrosion, Bureau of Mines Bulletin No. 233.
Corrosion Symposium, Am. Chem. Soc., Apr., 1925. R. E. Wilson and W. H. Bahlke, Special Corrosion Problems in Oil Refining, *Ind. & Eng. Chem.*, Apr., 1925, p. 355.
Ismar Ginsberg, Corrosion in Oil Refining Plants, *Refiner & Natural Gasoline Mfr.*, July, 1925, p. 40.
G. M. Enos, Fundamental Factors in Corrosion, *Ind. & Eng. Chem.*, Aug., 1925, p. 793.
Wood, Sheely, and Trusty, Corrosion Effect of Naphtha Solutions of Sulfur and Sulfur Compounds, *Ind. & Eng. Chem.*, Aug., 1925, p. 798.
P. H. Jones, Corrosion Problems in Petroleum Refining, Am. Chem. Soc., Los Angeles Meeting, Aug., 1925.

[4] F. H. Rhodes and H. J. Haon, Jr., Reclamation of Lubricating Oil from Crank-case Oil, *Ind. & Eng. Chem.*, Jan., 1925, p. 25.
C. M. Larson, Better Crank-case Draining Service, *Ind. & Eng. Chem.*, May, 1925, p. 476.
Flowers, McBerty, and Reamer, Deterioration and Reclamation of Used Automobile Crank-Case Oil, *Ind. & Eng. Chem.*, May, 1925, p. 481.
D. P. Barnard, 4th, The Effect of Crank-Case Dilution, *Ind. & Eng. Chem.*, Mar., 1925, p. 278.

and practical means of measuring their lubricating value should be developed.

Lubricating oils themselves should be the subject of research with a view to increased lubricating properties. Reports from Germany[1] indicate a decided improvement by subjecting thin, low-viscosity oils to a glow discharge of relatively high-frequency electricity, producing lubricating oils of remarkably high viscosity and without change of other physical properties.

PRODUCTION OF LIQUID FUEL AND LUBRICANTS FROM OIL SHALE, COAL, AND LIGNITES

The vast deposits[2] of oil shale, coal, and lignite which promise an almost unlimited supply of liquid fuels and lubricants for the future, can be called upon at such a time as the cost of recovery is justified by the demand. In the meantime considerable experimental and development work[3] is being undertaken and should be encouraged.

The monograph "Shale Oil" issued by the American Chemical Society[4] is the most important contribution to the literature of the subject during the year.

PHYSICAL PROPERTIES OF PETROLEUM AND ITS PRODUCTS

Underlying all problems relating to the handling, transportation, distillation, absorption, condensation, heating, and cooling of petroleum, is the necessity for full and accurate knowledge of its physical properties, both as liquid and vapor, together with their variation with temperature and pressure. The density, specific heat, latent heat of vaporization, viscosity, thermal conductivity, vapor tension, surface tension, absorption coefficients, etc. enter into almost every problem.

The fact that petroleum itself is not a definite chemical compound but is a complex mixture of a large number of hydrocarbons in widely varying proportions, makes it practically impossible to obtain general data which may be considered applicable in all cases. Such data may, however, be determined experimentally for the particular petroleum oil under consideration. When a sufficiently large number of such specific data have been secured covering a wide field, conclusions may be drawn as to mean values, which may then be applied with some assurance of reasonable accuracy, to the problems at hand.[5]

Without such fundamental data scientific analysis and solution of problems is seriously handicapped. Some of the data can be secured by simple apparatus and without great technical skill in its use, in other cases this is not so. The industry would be benefited, for instance, by the development of simple and accurate apparatus for determining the specific heat, latent heat, thermal conductivity, etc., of petroleum products.

TESTING OF PETROLEUM PRODUCTS[1]

The American Society for Testing Materials, which fathers all standards relating to petroleum and its products, adopted, at its annual meeting in 1925, new standards as follows: For methods of test for penetration of cup and railroad greases, for color determination by means of the Union colorimeter, for neutralization number of petroleum products and lubricants, for burning quality of long-time burning oil for railway use, for distillation of natural-gas gasoline.

Revision of existing tentative standards were adopted for: Methods of testing for viscosity of petroleum products and lubricants, for distillation of gasoline, naphtha, kerosene and similar petroleum products, for cloud and pour points of petroleum products, of testing gas oils.

Accurate standard methods for determining the gasoline contents of natural gas, and the gasoline contents of absorption oils are needed in the natural gasoline industry.

RESEARCH WORK IN PROGRESS

A great deal of research is being undertaken in connection with the work of the petroleum industry. Much of that which is being done at the present time will not become public until some future time, while the results of some will never be given to the world. This, of course, is not entirely as it should be.

The Bureau of Mines,[2] among other problems, is engaged upon investigations of methods leading to improvements in equipment for the fractional distillation of petroleum, methods of separating wax from wax distillate, preparation and testing of lubricating oils from different distillate, preparation and testing of lubricating oils from different crudes, of treating petroleum distillate particularly those obtained by pressure distillation.

ECONOMICS

The findings of the committee of the American Petroleum Institute on supply and demand, based upon an exhaustive study of the past, present, and future situation, should be read by all those interested in this phase of the subject. In general the main conclusions reached are that:

There is no imminent danger of the exhaustion of the petroleum reserves in the United States.

It is reasonable to assume that a sufficient supply of oil will be available for national defense and for essential uses in the United States beyond the time when science will limit the demand by developing more efficient use of, or substitutes for, oil, or will displace its use as a source of power by harnessing a natural energy.

Current supply and demand cannot stay in balance, since the amount of both supply and demand are constantly changing. Generally current supply will exceed or be less than current demand, creating surplus or shortage, and either condition will be reflected in price, but price will in time correct either condition.

It is further estimated that there are recoverable by present methods of flowing and pumping from existing wells and acreage thus proven five billion, three hundred million barrels of crude oil, after which there will still remain in this area twenty-six billion barrels of crude which can be largely recovered by improved and known processes when the price justifies. Improved methods of deep drilling below the present oil sands are expected to disclose

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[1] Elbert C. Isom, Increased Viscosity of Lubricants, *Oil & Gas Journal*, Aug. 20, 1925.

[2] American Petroleum—Supply and Demand. A Report to A.P.I., McGraw-Hill Book Co., 1925.

[3] M. J. Garvin, Oil Shale, Bulletin No. 210, Bureau of Mines.

S. D. Kirkpatrick, What about Oil Shale? *Chem. & Met. Engrg.*, Oct. 20, 1924, p. 611.

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G. W. Wallace, Making Shale-Oil in California, *Chem. & Met. Engrg.*, Feb. 9, 1925, p. 237.

Some Signs of Progress in Oil-Shale Development, *Chem. & Met. Engrg.*, Feb. 23, 1925, p. 324.

[4] R. H. McKee, et al., Shale Oil, Am. Chem. Soc. Monograph. The Chemical Catalog Co.

F. Fisher, Liquid Fuels from Water Gas, *Ind. & Eng. Chem.*, June, 1925, p. 574.

J. C. Morrell and G. Egloff, Cracking of Low-Temperature Coal Tar and Conversion Products, *Ind. & Eng. Chem.*, May, 1925, p. 473.

The Triumble Oil Shale Cycle-Distillation Plant, *Combustion*, vol. 12, no. 5, May, 1925, pp. 354–355. Reviewed in MECHANICAL ENGINEERING, July, 1925, p. 581.

[5] W. R. Eckart, Specific Heat-Specific Gravity-Temperature Relations of Petroleum Oils, MECHANICAL ENGINEERING, July, 1925, p. 535.

E. H. Leslie and A. R. Carr, Vapor Pressure of Organic Solutions, *Ind. & Eng. Chem.*, Aug., 1925, p. 810.

Edward H. Zeitfuchs, The Thermal Expansion of California Petroleum Oils.

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S. E. Campbell, Some Observations of the Contraction of Blends of California Crudes and Casinghead Gasoline, Am. Chem. Soc., Los Angeles Meeting, Aug., 1925.

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[1] A. R. Fortsch and R. E. Wilson, Measurement of Absolute Viscosity of Light Distillates with Saybolt Thermo-Viscometer, *Ind. & Eng. Chem.*, Mar., 1925, p. 291.

R. Stevenson and H. H. Stark, Equilibrium Vaporization of Gasoline, *Ind. & Eng. Chem.*, July, 1925, p. 679.

D. P. Barnard and R. E. Wilson, Dew Points of Gasoline-Air Mixtures, *Ind. & Eng. Chem.*, Apr., 1925, p. 428.

Howard H. Vesper, Laboratory Distillation Analysis of Petroleum, with Special Reference to Southern California Crude Oils, Amer. Chem. Soc., Los Angeles Meeting, Aug., 1925.

[2] F. B. Tough, *Oil & Gas Journal*, Jan. 29, 1925, p. 144.

H. H. Hill, What the Bureau of Mines Does for the Refiner, *Oil & Gas Journal*, Feb. 25, 1925, p. 98.

many area deposits not hitherto available and which will be equivalent to the discovery of new fields. The major oil reserves of the United States lie in some one billion, one hundred million acres of lands, which have not been fully explored but in which geology indicates oil is possible.

In addition are the vast deposits of oil shale, coal, and lignites which are so huge as to promise an almost unlimited supply. Supplies of oil in countries to the south with large petroleum resources will find a natural market in the United States and have an influence upon the consumption of American reserves.

The supply of petroleum will last longer with more efficient utilization. Improved methods in refining, principally "cracking," have already increased the supply of gasoline. This will be further augmented by the "cracking" of fuel oil, which in turn will eventually reduce the supply of fuel oil so as to remove it from competition with coal.

Waste in the production, transportation, refining, and distribution of petroleum and its products was found to be negligible.

Opportunities for Engineers in the Petroleum Industry

The petroleum industry, owing to the diversified nature of its activities, is a fertile field for the application of technical knowledge in all its branches. Its problems are such as to demand engineering ability of a high order. The work is not confined to any specialized field, and the services of geologists, mining engineers, civil engineers, mechanical engineers, electrical engineers, marine engineers, and chemical engineers are needed and made use of.

In the earlier days development from force of circumstances was brought about almost entirely by empirical methods, when the pioneers had to feel their way step by step without much to guide them except what had been done in other fields somewhat allied in nature, experience was, as usual, the great teacher; and the petroleum industry then developed a large number of experienced practical oil men. To these men great credit must be given for their accomplishments and for the progress made in the past. Practical experience in the petroleum industry is essential, as its complex problems do not in most cases lend themselves to exact scientific solution. The practical oil men have, however, recognized the beneficial results gained by the application of technical knowledge to their problems, with the result that for some time there has been a gradually increasing influx of technically trained men into the industry.

Institutions of higher education, for some years past, have been called upon extensively by the industry to supply recruits for their engineering forces. Some universities, where the demand has been the greatest, due to proximity to the large oil fields, have felt it desirable to introduce special courses in petroleum engineering. However, owing to the wide activities of the industry the graduates of the older and more general courses of mechanical, civil, and chemical engineering also find equally ready employment.[1]

There is no question, however, but that the general engineering training, due to the necessary contacts and diversity of technical knowledge required, should stress particularly the fundamental sciences of physics and chemistry, particularly the former. A knowledge of geology is an asset. Many students supplement their college training with summer work in the oil fields. Dr. Masson[2] recommends that refiners employ more young technical men, and suggests that they be employed before graduation so that they could combine the practical plant training with their studies.

Some of the oil companies have regular supervised training schools for the young engineers entering their employ.

From the foregoing and the general outline of the activities of the industry as presented in this survey of recent progress, it will be seen that the opportunities for engineers in this line of work are extensive and that the problems being solved are complicated in many ways so that they call for men with sound and thorough technical training, ability, and experience.

W. R. ECKART, *Chairman.*

Progress in Railroad Mechanical Engineering

Contributed by the Railroad Division

Executive Committee: C. E. Chambers, *Chairman*, A. F. Stuebing, *Secretary*, James Partington, F. W. Mahl, A. E. Ostrander, and R. S. McConnell

DEVELOPMENTS in mechanical engineering as applied to railroads center largely about the motive power. During the past year many innovations have been introduced in steam locomotives and also in locomotives driven by internal-combustion engines.

One of the problems that is now engaging the attention of many engineers is the use of higher boiler pressures in locomotive service. About 30 years ago there was a movement toward increased pressures which rose about 140 lb. per sq. in. to 200, and in some cases 250 lb., over a period of about 10 years. An investigation of high steam pressures conducted by Dr. W. F. M. Goss proved that greater economy could be obtained by increasing the size of the boiler and firebox, thus lowering the rates of combustion and evaporation, or by using higher superheat, than by increasing the pressure above 200 lb. This checked the movement toward higher pressure and for about 20 years pressures of approximately 200 lb. have been standard. The adoption of pressures of 250 lb., and in one case 350 lb., on recent locomotives is primarily due to the need of developing more power in the restricted space available for the boiler and cylinders. The highest pressures now being tried are beyond the range of the earlier experiments and involve changes in ratio of expansion, so it seems certain that additional economy will be secured.

The most notable high-pressure locomotive now in service is the *Horatio Allen*, designed by Mr. John E. Muhlfeld and built by the American Locomotive Company for the Delaware & Hudson. The working pressure on this locomotive is 350 lb. per sq. in. The boiler has a water-tube firebox and the cylinders are cross-compounded. The New York, New Haven & Hartford has a locomotive with the McClellan water-tube firebox which carries 250 lb. pressure. The Pennsylvania Railroad has several hundred locomotives operating at the same pressure. These have the conventional type of locomotive boiler with stayed firebox.

The three-cylinder locomotive, reintroduced by the American Locomotive Company in 1922, has been gaining favor and nearly 100 are now in service in this country. The advantages of this type are the more uniform tractive force and the division of the work between three sets of machinery instead of two. Tests already made have shown favorable operating results, and if longer service indicates that the addition of machinery between the frames does not increase maintenance costs, three-cylinder locomotives will probably come into extensive use.

Experiments are being conducted with the uniflow principle as applied to locomotives, but developments up to this time do not seem to show any marked advantage. Turbine locomotives are still in the experimental stage. While some designs show very good fuel economy, the high first cost and the complication of the machinery and accessories do not make this type attractive to railway operating officers.

There is an evident tendency toward the use of larger grate areas to reduce the rate of combustion and increase combustion efficiency. The most notable example is the 2-8-4 type locomotive

[1] Hollis P. Porter, The Engineer in the Oil Field and Oil Industry Leadership, Tulsa Section Meeting, A.S.M.E., April, 1925.

[2] Dr. H. J. Masson, Knowledge and Experience in Oil Refining, Nat. Pet. Assn., Cambridge Springs, Pa. Meeting, Apr., 1925.

recently built by the Lima Locomotive Works, which has 100 sq. ft. of grate area.

New locomotive wheel arrangements introduced during the past year include the 2-8-4 type already mentioned, the 2-10-4 type, and the 4-10-2 type.

No important developments in locomotive accessories have occurred during the year, but the use of devices for heating the feedwater has become more general. Three types are now in use: the open heater, the closed heater, and the exhaust-steam injector. Auxiliary engines for utilizing the weight of the trailer or tender axles to develop additional tractive force are extensively used.

Considerable progress has been made in the application of internal-combustion motors to locomotives, and some of the experimental types now in service apparently represent a long step toward the achievement of a satisfactory Diesel locomotive. A unit of 1000 hp. of the Diesel-electric type was completed a few months ago by the Baldwin Locomotive Works. The engine is of the inverted V-type, operating on a two-stroke cycle. The two crankshafts are geared together. The driven shaft, running at higher speed than the crankshaft, is connected to an electric generator. The locomotive is driven through electric motors mounted on the trucks.

Another Diesel-electric locomotive of smaller capacity, built by the Ingersoll-Rand Company, General Electric Company, and the American Locomotive Company, is now in service. This is a 60-ton engine of 300 hp. capacity. They are also building an engine of 600 hp. capacity and intend increasing this to 750 hp., which may be used in a 2-unit type, making 1500 hp. possible.

The development of freight cars is proceeding along the lines of greater refinement of detailed design. The American Railway Association has developed standard designs for single-sheathed and double-sheathed box cars of 40 and 50 tons' capacity. In connection with this work, the Association made the most complete analysis of stresses in freight cars that has been undertaken thus far. Important research work on power brakes for long and heavy trains has recently been started by the Association.

Self-propelled passenger cars are now used on a large number of railroads and are becoming recognized as satisfactory and economical means in caring for passenger traffic on branch lines. The early cars of this type were practically adaptations of highway buses. The present tendency is toward the use of larger equipment, which introduces numerous problems in the design of power plant and transmission. Electric, hydraulic, and gear drives are all being employed in this service.

An interesting innovation which has developed in England and is now being tried in this country is the so-called "articulated" car with two bodies mounted on three trucks, or three bodies mounted on four trucks, one unit now being in operation on the Brooklyn Rapid Transit Lines.

Engineering advances in motive power and equipment are directly responsible for the noteworthy results that are being obtained in railroad operation. One of the significant changes that has occurred in the last few years is the extension of locomotive runs from single divisions of 100 to 150 miles to two or more divisions. On some railroads locomotives are regularly taking runs of over 500 miles without being detached from the train. A locomotive recently made the run from Harmon, 30 miles north of New York, to Chicago and return with no other attention being made than supplying fuel, water, and oil. The economical use of fuel is receiving much attention from designers and operating officers. The result is apparent in the steady reduction of the amount of fuel consumed per thousand gross ton-miles.

Viewing the situation as a whole, it is evident that advances in mechanical engineering are largely responsible for the achievement of the railroads during the past year in handling greater traffic than ever before with increased efficiency and freedom from car shortage or congestion.

C. E. CHAMBERS, *Chairman.*

Progress in Aeronautics as Related to Mechanical Engineering

Contributed by the Aeronautic Division

Executive Committee: Archibald Black, *Chairman*, Alex. Klemin, *Secretary*, Sanford A. Moss, Geo. W. Lewis, Edwin E. Aldrin, and Starr Truscott

THE development of outstanding interest in aeronautics in the United States during the past year has undoubtedly been the renaissance of public interest in the application of aircraft in transport. The inauguration and extension of air routes has been proceeding in Europe with more or less regularity under the persuasive influence of extremely liberal government subsidies. As a result, a network of European airlines has been brought into existence. This network looks most imposing until it is pointed out that not a single line could exist were the heavy subsidies discontinued. In the United States many attempts were made to establish routes during the several years since the close of the war. Lack of government subsidies, lack of public support, insufficient capital and—only too frequently—neglect of certain basic principles of transportation combined to doom many to failure. An outstanding exception was the U. S. Air Mail Service, operated by the Post Office Department. This service, although carried on at a heavy loss, served a very useful purpose in many ways.

THE ENCOURAGING OUTLOOK FOR UNSUBSIDIZED SERVICE

In the field of air transport, the most important development of the year has probably been the inauguration of night air-mail service between New York and Chicago. The activity of the Ford Motor Company is also worthy of note. Early in the year this company (which had been quietly interested in aeronautics for several years) began operation of an air-transport system between some of its plants. The initiation of the Ford lines was closely followed by announcement of the plans of National Air Transport, Inc. This company was organized by a number of the leading business men of the United States for the purpose of establishing air-transport routes on a large scale. The two announcements created a profound sensation among the public and resulted in a general acceptance of the idea that air transport had "arrived." Responding to the invitation of Air Mail officials, several prominent airplane constructors produced some new types of airplanes suitable for carriage of mail and similar matter. Following the development of these mail-carrying airplanes, the Post Office Department called for bids for the carriage of mails over several proposed routes and received a number of offers. Certain of these bids have been accepted, and operation of the routes is to begin in the immediate future. At the same time, gradual extension of European airlines has been continued. Many of the existing airlines have shown important increase in traffic but none has yet reached the stage of self-support independent of its subsidy. The outlook is, however, encouraging in this regard, and it seems probable that at least one or two routes will soon become free of dependence upon subsidies.

REDUCTION IN COST OF NIGHT-FLYING EQUIPMENT

The most marked advance in the development of night-flying equipment has been in the production of less expensive apparatus. Most of the equipment previously developed was very expensive to install—indeed, from the commercial viewpoint it was prohibitive. However, the present year saw the introduction of a full line of electrical equipment of high reliability and much of which is

available at considerably lower cost than the older apparatus which it displaces. While the equipment available for night flying is now thoroughly practicable, further work yet remains to be done. Among such problems might be listed the matter of further reduction in initial cost and increase in the range of the lights in fog. Some experimental fog-piercing lights have been built and are now being tried out. The establishment of night service with a lighted airway from New York to Chicago, previously referred to, marks an important advance in night flying, as the territory flown over presents more than usual difficulty.

TRENDS IN AIRPLANE DESIGN AND CONSTRUCTION

In this field one of the most interesting products was the Loening amphibian built for the U. S. Government and used in connection with the MacMillan arctic expedition. This design possesses many points of unusual interest, notably the arrangement of folding the wheels into the single float, and the inverted engine installation. The inverting of the engines, as in this Loening design, is also being tried out in some other designs, and possesses advantage in allowing greater vision and better propeller clearance. Continued improvement has been shown in airplane design but this improvement, during 1925, has been due mainly to refinement rather than to radical changes. The activity of the past few years in the construction of gliders seems to be gradually shifting to the construction of very small-powered airplanes. In the United States some work has been done experimentally along this line, but the greater attention has been given to the two- and three-seat type. A vivid illustration of the seaworthiness of modern flying boats was given in the performance of the Navy PN-9, which remained afloat for several days after landing in the Pacific and was finally towed to land with no serious damage to the hull.

The development of insecticide dusting on a commercial scale resulted in the production by the Huff-Daland Company of a Liberty-engined "duster" airplane of 1000 lb. capacity.

FAITH IN THE RIGID AIRSHIP

Activity in the airship field was marred by the destruction of the U. S. N. *Shenandoah*, with a loss of several lives, in a severe storm over Ohio. While there is no doubt that airship development will be seriously affected by this disaster, the work will certainly be continued. It seems very questionable if airships can be designed to withstand extreme conditions such as the *Shenandoah* encountered, but the accident will probably result in the provision of greater structural strength and more power in future designs. The increased power becomes desirable for the purpose of avoiding storm areas more readily. As indicating the continued faith in rigid airships, appropriations have been asked for the construction of a still larger type. In the meantime, work on non-rigid and semi-rigid airships is being continued. One of the interesting developments in connection with airship activity was the construction of a very novel type of mooring mast by the Ford Motor Company at Dearborn, Mich.

TRENDS IN AERONAUTIC POWER-PLANT DESIGN

A considerable amount of research and experimental construction is still being carried out on engines. Marked advances have been made during the past few years, particularly in the further reduction of weight ratio (to horsepower) and in further increase in reliability. Through the important advances made in the construction of air-cooled engines there is a very distinct tendency toward this type for all sizes up to, possibly, 500 or 600 hp. Both here and in Europe air-cooled engines developing up to 400 hp. have been produced, and the larger units are now undergoing what may be regarded as a period of probation. It is by no means improbable that the power of the air-cooled engine may be pushed well above the 600-hp. mark in the near future. Important advances have been made in extending the life of all types of engines, a feature which will become of major importance with the development of air transport.

MANY INSTRUMENT PROBLEMS HAVE BEEN SOLVED

To meet the requirements resulting from the constantly increasing speeds of racing airplanes, air-speed indicators have been developed which read up to 350 miles per hour. The development of gasoline gages of the hydrostatic type, which has been under way for several years, has now reached the stage where this type of instrument is considered thoroughly practicable. On account of the increasing number of instruments required in airplanes and to facilitate their arrangement and use, instruments of the vertical type have been developed and are coming into general use. It is really surprising how compact and how practical the instrument-board arrangement can be made with this type. The ground inductor compass, which has also been under development for a few years, has now reached the stage of practical utility.

NEW ACCURACY IN AERIAL PHOTOGRAPHY

The work in this field consisted mainly of refinement and improvement of equipment previously developed. Aerial photography has, for several years, been one of the best established branches of aeronautical activity and it is steadily growing. Technical progress is being made chiefly along the lines of increased accuracy, greater range of camera, and greater independence of light conditions. Some advance has been made in this direction through increase in sensitivity of the film used. The stereoscopic method of plotting elevation contours on aerial photographs has advanced to the stage where a high degree of accuracy is possible.

AERODYNAMIC RESEARCH IS CONTINUOUS AND FRUITFUL

Wind-tunnel and full-scale investigation of wing sections, bodies, and parts of aircraft has been steadily continued. This work reached the stage, a few years ago, where progress is made only in very small steps at a time. Consequently, while progress has been made in 1925, it is difficult to list all of the important points. However, there might be mentioned the work accomplished in the development of high-lift wings through auxiliary flaps, etc., the experiments with fins placed at the tips to decrease end loss, and the experiments with devices to automatically prevent "stalling" of airplanes at low speeds.

BIBLIOGRAPHY OF AERONAUTICS IN 1925

On account of the very extensive contributions to aeronautical literature during 1925 it is not practicable to attempt to list other than those published in book form. At the same time, some of the most important publications took the form of technical papers, magazine articles, and such.

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OUTSTANDING PROBLEMS IN AERONAUTICS, 1925

Airships

1 Further study of the stresses in rigid airships encountering unusual weather conditions.

2 Study of landing facilities and facilities for loading and unloading of airships used for transport.

Aerodynamics

1 Investigation of the relative resistance of air-cooled and water-cooled engine installations.

2 Study of methods of eliminating or quickly stopping the spinning of airplanes.

3 Study of large-capacity bodies for transport airplanes and of their effect upon tail controls.

4 Wing combinations permitting further increase in speed range.

5 Further investigation of maneuverability and controllability, with particular reference to lateral stability and control at stalling angles and beyond.

6 Further sudy of interference of propeller slipstream, body, and wings.

Air Transport

The major problems confronting us in commercial air transport are economic rather than technical. Problems concerning the "selling" of air transport to the public and the development of popular "demand" cause the technical problems to sink into relative insignificance. At the same time, these technical problems actually do exist and the more important or more pressing ones might be considered to be:

1 Operation of aircraft through fog. (This problem has been partly, but not wholly, solved through the development of the earth inductor compass.)

2 Extension of engine life or (what is the equivalent) the reduction of the initial cost of engines.

3 Simplification of maintenance of airplanes and engines, including rapid demountability and interchangeability of parts.

4 Development of methods of quickly loading and unloading large airships against the time when these will be used in transport.

Naval and Military

Naval and military problems may be viewed at present as consisting mainly of continuing the development and refinement of airplanes and their equipment and it is difficult to list any few items which can be classed as *outstanding* problems. It seems to be generally agreed that there is room for further standardization of small parts and equipment used in military and naval aircraft.

Research

1 Investigation of duralumin corrosion and "decay," and the development of suitable protective means, probably represent the most outstanding problem under the head of research.

2 The development of methods of protecting the interior of metal tubes against corrosion represents a research and manufacturing problem of great importance.

3 Further investigation of the fatigue of aircraft materials (particularly steel and duralumin) and their fastening means when subjected to vibration.

General

1 Investigation of methods of decreasing fire hazard. Some work of importance has already been accomplished along this line but the problem is not yet fully disposed of.

2 Development of "crash-proof" compartments for passengers, pilots, and cargo in airplanes.

ARCHIBALD BLACK, *Chairman.*

Progress in Printing as Related to Mechanical Engineering

Contributed by the Printing Machinery Division

Executive Committee: Wm. C. Glass, *Chairman*, Chas. F. Hart, Winfield S. Huson, Edwin J. Peirce, and John H. Williams

AS A FOREWORD to the presentation of activities in the printing industry, it would be well to direct attention to the different methods for producing the printed sheet.

To the general reader a printed sheet carries no impression as to the means employed to produce it; the only effect is that conveyed through the eye as to the subject-matter. The attempt here is to broaden vision particularly where interest will be aroused to a broader grasp of the status of printing, its engineering achievements, and its place in the world's vital needs. It is a prime essential to the constant progress of knowledge of all that is conveyed in the fields of economics, the arts, and the sciences, and as well the working out of civilization to that higher plane reaching toward idealism and ever worth striving for.

There are several methods extant, each a subject of intense problems in procuring the final result, and it is of these methods and the attendant machinery and procedure we wish to speak.

Letter-press printing, in which the printing is done from raised characters, occupies the largest field, as found for instance in newspapers and in periodical and magazine work. It is the earliest method and has persevered through time.

Following this comes planographic printing, in which the printing is done from a plane or smooth surface.

Then there is collotype printing, which is produced by printing from a hardened photographic film mounted on a suitable base, and resembles somewhat in its operation letter-press work.

The planographic method has been developed into what is known as "offset" printing, in which the paper is printed from an impression first offset on to a rubber blanket and thence on to the sheet.

As an opposite of letter-press in the preparation of the matter to be printed, there is the intaglio or gravure process, in which the matter is acid-etched below the surface of a plane or cylinder, the tonal effects of color being obtained by varying depths of the etch; in this respect differing from steel-plate engraving, which is intaglio but where the effects are had by varying the width of graved lines.

LETTER-PRESS PRINTING—THE DAILY NEWSPAPER

As to letter-press printing, the daily newspaper stands in the forefront as a familiar instance. The production of a daily paper starts far ahead of the final running of the press, for as news or other matter for an edition is received it must be put into type, picture, or display, and so arranged as to be within page limits. In the preliminary work necessary before "going to press" there is employed some of the most ingenious machinery ever evolved by the human brain.

The line type-casting machine stands out as example; copy is given an operator seated before a keyboard, and as keys are touched, small brass matrices having specific characters embedded in them are released and a line formed from which a slug of the required width is cast; these slugs are assembled in column formation and the matrices are returned to the magazine from which they were released, each matrix finding its proper place in the distribution.

All the operations are automatic except touching the keys, and even here there are machines where type casting and setting are automatically operated from a perforated strip of paper, each perforation controlling a separate character which is cast as a unit and then assembled in line formation.

As columns of matter are completed they must be proofed, corrections made, and finally imposed with other matter into a page. By the wonderful method of wire transmission, telephotography gives to the public pictures of scenes almost at the moment of happening. Then, too, there are display advertisements, all going to make up a paper of short duration, but yet vital to our knowledge of every-day events and existence.

Were it possible where large editions are necessary to print direct from the pages as they are completed, the printing could start from flat pages, or "forms" as they are technically termed. For papers of comparatively small circulation, such as some country papers, this is done, but the enormous circulation of city papers requires the newspaper rotary press, which has been developed to a high degree of efficiency not only as to quality of output but also as to quantity. Speed is ever insistent in the newspaper plant; nothing is ever at rest, particularly where there are several daily editions. Machinery and men work at high tension, for, as we can well understand, a delayed edition is dead so far as the value of

its news of the moment is concerned—hence all the factors entering into production must coördinate in all departments and without failure in any one.

ROTARY PRESSES AND CURVED PLATES THEREFOR

Since rotary presses are used, the pages must be curved to fit cylinders, and here again we find displayed ingenuity of high order. To make these curved plates the forms are placed on a matrix-rolling machine preparatory to the making of a matrix. This matrix consists of several thicknesses of paper pasted together with fireproof paste and placed in a damp condition on the form, which latter, when passed through the matrix roller, is forced into the matrix. This matrix is then dried, stripped from the form, and trimmed, when it is ready for stereotype plates to be cast from it in a curved casting box into which the thin matrix readily curves. In early days the casting box was a unit in itself, the metal being hand-poured from a ladle, but today we have automatic and semi-automatic casting machines into which hot metal is pumped and then water-cooled. The stereotype plate thus cast is then stripped from the matrix and passed on to a tail cutter which separates the sprue from the plate and forms the bevel edge for clamping to the press cylinders; thence it goes to the shaving knife which shaves out the underside of the plate to a true surface. All this being done in a fraction of a minute conveys some idea as to the thought and ingenuity that has been built into the stereotype casting machine, particularly where hot metal is involved and where a slight leakage would be fatal to the prompt production of the plates.

While it is customary to figure newspapers in units of eight pages, the modern high-speed rotary press is built double width or four pages wide, each page taking a semicircumference of a plate cylinder, or eight plates in all for one side of the sheet, which, duplicated for the other side, gives sixteen pages per revolution.

An average speed is 250 r.p.m., which means 15,000 sixteen-page papers per hour, the surface speed of the web of paper being printed being approximately seventeen feet per second. As the demand for a metropolitan daily calls for more than sixteen pages and a larger hourly output than 15,000, additional units are required. If a double octuple press is taken as an example, there would be eight units in the one installation capable of producing, were all the units run at once, 120,000 sixteen-page papers per hour, each unit being fed from its own roll or web of paper. All units are not usually run as a whole, some being held in reserve, but even at the highest output the voluminous nature of large dailies indicates the necessity for additional presses, it being not unusual to have ten or a dozen presses to meet the demand. A double octuple press arranged tandem fashion requires a floor space of 72 ft. by 10 ft.; if arranged tier fashion the length would be reduced and the height increased. In modern practice the rolls of paper are often placed in an apartment under the press proper, as it will be seen that two levels are involved.

As to weight, 250 tons is a close approximation; the power required is 150 hp., two motors in present practice being used, one (about 15 hp.) for "inching" the press and for starting, and a larger one for picking up the load as speed increases.

At least $200,000 can be accounted for in a press installation, so when one realizes the number of large daily papers printed hour after hour, some idea can be gained as to the machinery needed to produce them.

Touching for a moment on materials handling and dealing with only plates and paper, to equip a double octuple press complete requires 128 plates and eight rolls of paper. The plates, which must be placed on the cylinders by hand, weigh about 50 lb. each, or a total of over three tons for one edition only. The paper rolls average over 1000 lb. each and are about 34 in. in diameter and 72 in. long, the web of paper being about four miles in length. Long as this web may seem, it is soon consumed in printing a few thousand papers. The roll-handling mechanism is another example of adaptation of a means to an end, for as soon as a roll is near exhaustion a full roll must be gotten under way with a minimum of delay, and for this purpose roll carriers are devised to supply fresh rolls at once to replace the exhausted ones.

There is one rotary press which is not only ingenious in its conception but also in its structural features. The stereotype plates used, instead of being semicircular, are tubular in form, there being only a longitudinal slot of margin width. The plate-cylinder bearings are carried in steel castings having thin necks joining them to the main housings and permitting a plate to be pushed on the cylinder, the neck passing through the slot. The plate cylinders are small, being half the diameter of the semicircular type, and while at first built for papers of moderate circulation, the press has been developed into one having large capacity and solving the problem of using a continuous stereotype plate around a cylinder.

PRINTING PERIODICALS

While the general practice in higher grades of printing, such as found in periodicals and magazines, is the same as for papers, there is a marked difference in procedure. Electrotype plates are used for the better quality of printing, and these differ entirely in the making from the stereotype plate. The face of a form is pressed into wax or sheet lead in a hydraulic press having in the larger sizes several thousand tons pressure. This mold is then put into a tank and a thin film of copper electrolytically deposited upon it, after which the film is stripped from the mold and backed up with lead alloy to the required thickness. The plate is then straightened and, if for a rotary press, curved to the proper radius. This curving must be done with the greatest care, for it will be evident that where color work is involved and successive plates must print their specific colors in exact register, if plates are stretched or distorted in any way they are useless. In reaching out for surer methods to produce perfect plates, particularly when curved, a method is being employed in which the plate is made plastic near to the melting point by bringing electric heating units in contact with it and then while warm bending it to the proper curvature, thus eliminating to a large extent the stretching which occurs when a plate is bent cold. There is a mass of interesting detail connected with these processes, but the confines of this paper will not allow of more than a general description.

LITHOGRAPHIC, OFFSET, COLLOTYPE, AND GRAVURE PROCESSES OF PRINTING

There is a branch of printing which has always been interesting, and that is lithographic or planographic work. In this the matter is first printed on transfer paper and then retransferred to a flat stone or sheet of metal, either sheet zinc or aluminum. A greasy ink is used, the process being based on the antagonism of oil and water. A plate is wetted or dampened, the water being rejected by the design, which is then inked, the oily transfer only taking the color.

From this method has been developed the offset process, in which the design is first printed on a rubber blanket and thence on the sheet which is carried by a companion blanketed cylinder, these soft surfaces permitting printing on paper that is rough-surfaced as compared with the smooth-surface stock necessary in direct printing. Offset printing is growing and is reaching into the newspaper field, one feature being the passing of the web of paper between two cylinders which print both sides simultaneously. Beautiful color work is also being done, as evidenced by the display work used in advertising as well as in magazine inserts.

Collotype printing is not as well known as the other methods, but is fast growing into commercial use. Photography enters into the process. A stripping negative is exposed and developed, and the film stripped, hardened, and deposited on a suitable base. As the whole field of the hardened film must print, its height above the base being slight, it is necessary to run a cut-out mask sheet over the sheet to be printed to prevent printing margins—which are printed on the mask, the picture only appearing on the sheet. Later developments have led to the adaptation of this process to the offset method, in which the film takes the place of the greasy design, the film being prepared to take ink and the remainder of surface taking the water. By this method the mask is not needed and subjects such as paintings, other works of art, and the like are reproduced with even better detail than is ordinarily the case, for the camera lens is sharper than the human eye.

It is almost unbelievable that a cylinder carrying a design can be rotated in a pan of ink as thin as ordinary oil and yet print. This, however, is the intaglio or gravure process which is becoming more and more common. It is also a photographic process; the pictures are made and transferred on to copper-faced cylinders, which are then rotated in an acid bath and the surfaces etched. Where there

are high lights the etch is slight; where heavy, the etch is deeper. The final tonal effects on the printed sheet result from the greater or less depth of ink carried in the etched depressions. When in the press the cylinder turns in the ink mass, the surface being scraped over by a thin blade which removes the ink from all but the etched portions. How successful this process is can be readily understood by a glance at the gravure sections of some of our daily or weekly papers.

RECENT DEVELOPMENTS

As to the outstanding developments during the year, there has recently been completed for the Government a rotary press capable of producing 6400 postal cards per minute. The plate cylinder carries 80 plates and makes 80 r.p.m., which means a daily production of 3,000,000 cards, printed, cut to size, stacked in lots of 25 or 50, and delivered ready to be shipped.

Larger newspaper presses are being regularly installed that are built right up to the minute for greater and better output.

Offset printing is being further developed, and presses for newspaper work are soon expected in the market. The production of color work by the gravure method is being closely pursued, and the difficulties encountered in register and color effect constantly studied. Some supplements with quite attractive pictures are already printed in colors.

The endeavor here has not been to go into deep engineering problems and solutions. They are to be found in printing as in our other industries, and the same application is constantly being used to make this industry always representative of the ever-progressive nature of our engineering achievements. The place of printing in our world activities is well summarized in the lines of R. H. Davis:

> I am the Printing Press, born of mother earth. My heart is of steel, my limbs are of iron, and my fingers are of brass. I sing the songs of the world, the oratories of history, the symphonies of all time. I am the voice of today, the herald of tomorrow. I weave into the warp of the past the woof of the future. I tell the stories of peace and of war alike. I make the human heart beat with passion and tenderness. I stir the pulse of nations and make men do braver deeds and soldiers die. I inspire the midnight toiler, weary at his loom, to lift his head again and gaze, with fearlessness, into the vast beyond, seeking the consolation of a Hope Eternal. When I speak a million people listen to my voice. The Saxon, the Latin, the Celt, the Hun, the Slav, the Hindu, all comprehend me. I cry the joys and sorrows every hour. I fill the dullard's mind with thoughts uplifting. I am Light, Knowledge, Power. I epitomize the conquests of mind over matter. I am the record of all things mankind has achieved. My offspring comes to you in the candle's glow, amid the dim lamps of poverty, the splendor of riches; at sunrise, at high noon, and in the waning evening. I am the laughter and the tears of the world, and I shall never die until all things return to the immutable dust. I am the Printing Press.

WINFIELD S. HUSON, *Member of Committee.*

Progress in the Wood Industries as Related to Mechanical Engineering

Contributed by the Wood Industries Division

Executive Committee: Wm. Braid White, *Chairman*, Paul H. Bilhuber, F. F. Murray, Grant B. Shipley, and Carle M. Bigelow

ENGINEERS, not without some reason, have been accustomed to think of the woodworking industries as highly empirical and unscientific, working by means of the rule-of-thumb and the shop tradition, and possessing no foundation upon which precise calculation of method could be built. On the other hand, engineers have not sufficiently recognized the fact that modern conditions have virtually abolished the ancient handcrafts in woodworking and have brought about a mechanization of method and process which now involves the use of machine tools of a precision and efficiency approaching those of the older engineering industries. In fact, a revolution has silently taken place in the practice of woodworking during the last few years, and it is now necessary to recognize that here has come into being a set of immediate engineering problems and interests growing out of modern changes in the conduct of ancient crafts, and likewise out of the many new births which have come forth from modern discoveries in the use and application of wood.

In fact, it is not too much to say that no professional division of the Society so much as this young one offers interesting, useful, and valuable opportunities to engineers, both old and young, veteran and apprentice.

Since the present is the first report which this Division has had to make of this nature, it will be advisable to state briefly the divisions into which the engineering side of woodworking naturally falls.

In the first place, there is a whole group of problems relating to the growing and obtaining of wood—to wood, that is, as a raw material. These are primarily what are known (1) as forestry and (2) as lumbering problems. Forestry problems are partly chemical, partly physical, and partly agricultural. They are not primary concerns of the mechanical engineer, but secondarily interest him greatly in their bearing upon the conservation of the supplies of standing timber, which at the present time are being consumed much more rapidly than they can be replaced by new growth.

Problems of lumbering are primarily mechanical and involve the use of much machinery in the forest, mostly specialized in type and including logging-railroad machinery, felling machinery, and so on. As the supply of standing timber diminishes, the scientific side of lumbering comes uppermost and demands close coöperation between forestry experts and mechanical engineers in order to prevent all preventable waste in the operations of felling trees and of transporting logs to the sawmill. So far, engineers have been content to rate the mechanical side of this industry as a mere incident of engine building; but it is evident that the whole question of obtaining the supply of timber must be considered hereafter in the light of scientifically gaged needs of the industry, determined and controlled by engineering methods. We are only at the very beginning of engineering coöperation here, but it is worth observing that the Wood Industries Division is finding itself able to coöperate with the Forest Products Laboratory of the Department of Agriculture in increasingly fruitful ways. During the Annual Meeting of the Society this year a paper is being presented before the session of the Wood Industries Division by a member of the Society who is on the staff of the Laboratory, upon the present status of research into the immensely important question of forest-fire prevention by the use of spark-arrester devices on spark-making machinery, such as locomotives, gas engines, etc., within or in the vicinity of forested land. Here is a large and purely mechanical-engineering problem which so far remains unsolved, in that no device of a thoroughly satisfactory nature has yet been brought forth. The fact that the interest of the Society has been enlisted in this important matter, however, entitles the Wood Industries Division to mark up a sign of definite progress at this early point along the road of the wood industries.

SAWMILL DEVELOPMENT

In the second place, preparation of wood for industrial use involves a group of engineering problems related to the design and building of machinery for cutting up timber into lumber. Sawmill machinery, as it is usually called, no longer consists of the simple portable engine and circular saw of ancient days. The modern sawmill comprises large power plants driving not only circular

but band saws, single or in gangs, planers, and similar machines, which cut up the logs into suitable sizes for various industrial uses and prepare them to a greater or lesser extent for immediate use, as for building purposes. The tendency is for the sawmill to go further and further into the preparation of lumber in stock sizes, more or less finished and ready, after seasoning, for immediate use. During the short time which has elapsed since the foundation of the Wood Industries Division, this tendency has been remarkably noticeable, and it is evident that the design and construction of sawmill machinery becomes increasingly complex and highly organized. Several members of the Society enrolled in the Wood Industries Division are engaged in sawmill-machinery manufacture. These engineers are giving much time and attention to securing standards for saw setting, to the end of eliminating waste and obtaining the utmost product from each log. During the Spring Meeting of this Society at Milwaukee last May, some important discussion was had of this subject and it has been ear-marked as a distinct branch of the activities of the Wood Industries Division.

PRESERVATION AND CONDITIONING

In the third place, the treatment of wood by preserving or by conditioning methods, to make it ready for use in exposed situations, or to put it into shape for fabrication in woodworking industries, comes into prominence. The railroads, great users of timber, are turning steadily to the use of preserving methods for prolonging the life of cross-ties, bridge timbers, poles, and similar articles, and one of the marks of woodworking progress during the past years is to be seen in the increasing tendency to this obviously scientific and valuable practice. Wood preservation constitutes a special branch of woodworking engineering, partly chemical, partly physical, and partly mechanical; and the Wood Industries Division considers it one of its important departments.

The subject of wood conditioning, or drying, constitutes almost a science and art of its own. From the first the Wood Industries Division has considered it as of major importance. One year ago a most interesting and stimulating discussion of methods for kiln drying and of dry-kiln design was held before the Division, and during the year there has been a steadily increasing interest in all branches of the subject. The tendency is for wood-using industries to concentrate their efforts upon artificial drying by means of the kiln in one form or another, to the exclusion of the less speedy method of air drying. The tendency is not wholly admirable, but at least the attention of engineers has now been aroused, and all signs point to a sincere attempt all around to put the whole question upon a sound basis.

PLY AND VENEER

In the fourth place, we have to deal with that special preparatory form of treatment which turns the log of timber into thin sheets or veneers. Wood construction built up of veneers or plies is today recognized as providing far greater strength and durability than solid woods can attain. Rims of grand pianos, panels of all kinds for cabinets, cases, and pieces of furniture, propellers of airplanes, and a hundred other constructions where lightness and great strength are to be combined, afford increasing opportunities for the use of plywood, and so for scientific design and construction of machinery for cutting the veneers and for gluing them up. The veneer industry is a large specialty by itself, and when the fancy hardwood veneers used for the outer finish of pianos, furniture, and cabinet work generally are included in the survey, it is easy to see that here is opened up a vast field for engineering investigation and research. The possibilities of plywood construction are only now being exploited on any large scale, but the possibilities are still an almost unlimited, and mechanical engineers can hardly find a better field for their talents.

WOOD MANUFACTURE

In the fifth place, we come to the vast field of wood fabrication, that is to say, of the manufacture of wood implements, and of the innumerable articles into the construction of which wood enters more or less completely. The whole great field of musical-instrument making, the furniture industry, the building of railroad cars, small wooden implements, toys, domestic appliances, etc., etc., all these and many others are included. Here a whole assemblage of different industries is to be found, It would be impossible to give even an outline of the engineering aspects of all these industries, many of which are very highly organized, and comprise chemical, physical, and mechanical problems in equal proportions. Wood is of all materials the one most nearly universal, and its uses are simply innumerable. A single industry, and that a small one, comparatively speaking, the piano industry, for instance, embodies one of the most complex of industrial processes—scientific, artistic, technological, and mechanical. And similar observations apply to many others. Nor is it possible to do more than barely mention such industries as wooden building construction. Pulp and paper questions likewise are not included in this summary, vastly important as they are, since a special activity of the Society is devoted to them.

MECHANICAL PROGRESS OF 1925

In this vast industrial classification now under survey, there have been many engineering events of interest during the year. The use of high-speed individual motors for driving machines is on the increase. Electrical prime movers, in fact, are becoming the rule. Questions relating to these are discussed at the present meeting of the Society before the Wood Industries Division. Materials Handling, which is in reality within the field of another Division of this Society, is coming in for increased attention as the need for reducing overhead and increasing production becomes more pressing. Discussion of such matters and research into them are the regular activities of the Wood Industries Division.

CLASSIFICATION OF THE DIVISION'S WORK

The great classes into which the work of the Wood Industries Division naturally falls might be briefly defined as follows:

1. Coöperation with Forestry Services in respect of the conservation of timber resources
2. Research into economical and waste preventing methods of lumbering
3. Scientific development of treating and preserving methods
4. Research into the application of dimension-cut lumber for general industrial use
5. Elimination of waste by standardization of cutting machinery
6. Development of more economical consumption by standardization of lumber grades
7. Application of machine-shop methods to woodworking
8. Development of standardized definitions, grades, test methods, and applications of external finishes, such as lacquers and varnishes, and of adhesive materials such as glue.

One final point must be noted. The educational system of the country has of late years shown a rather deplorable neglect of woodworking as a field for vocational training. A recent questionnaire sent out by the Wood Industries Division to some hundreds of elementary and high schools throughout the country has already been very largely answered and at this meeting of the Society the tabulated results are being presented. They show what must be done to secure educational interest in the training of American youth in woodworking dexterity. No other sort of manual training approaches this in facility and general usefulness as respects the training of hand and eye. The Division considers this inquiry one of its most important activities during the year just past.

The wood industries are enormous in magnitude and second to none in importance. They offer to engineers a field virgin over large tracts and nowhere thoroughly cultivated, upon which their talents may be profitably expended. They are fresh and unspoiled, they are just emerging into what may be called engineering consciousness, and they demand engineering talent. To some extent engineers must in them be missionaries to the heathen; but the process of conversion will not be found extraordinarily difficult. These industries are increasing constantly in size and in activity. They call for new ideas and for new blood. Their engineering progress during the past year has been astonishing, and the Wood Industries Division confidently anticipates more, not less, work during the year to come in holding up its end in their development.

WILLIAM BRAID WHITE, *Chairman.*

Progress in Textile Mechanical Engineering

Contributed by the Textile Division

Executive Committee: Geo. H. Perkins, *Chairman*, James A. Campbell, *Vice-Chairman*, Sidney B. Paine, James W. Cox, Jr., *Secretary*, Henry M. Burke, and F. A. Flather

THE magnitude of textile industry may best be emphasized by the accompanying statistics taken from the Department of Commerce Year Book for the year 1924.

Among the sixteen major manufacturing groups there classified, Textiles and Their Products, including wearing apparel, ranked as follows for the year 1923:

	No. or value	Rank	Per cent increase from 1914
Wage earners (average)	1,704,000	1st	13.2
Wages	$1,727,000,000	1st	155.5
Value added by manufacture	$4,079,000,000	1st	184.0
Cost of materials	$5,396,000,000	2nd	...
Value of products	$9,487,000,000	2nd	174.6
Power (horsepower)	3,802,000	2nd	39.4

While the totals of value given involve much unavoidable duplication owing to the inclusion of wearing apparel, the value of the products of the textile mills proper, employing a total of 1,100,000 people, amounted to $5,552,000,000 for the year 1923.

The value of wearing apparel and other articles made from textile products for the same year amounted to $3,937,000,000, with a total of 627,000 people employed.

During the past year textiles have been gradually recovering from the serious depression of 1924, and many observers now believe that the industry is entering upon an extended period of progress and prosperity.

In the revival of the industry the dominating feature has been the extensive demand for the most widely diversified line of "fancy" and novelty fabrics of varied color, design, construction, and raw materials. The production of such fabrics has necessitated either entirely new equipment or extensive adaptation of existing machinery and processes to meet the situation. Many plants equipped solely for staple lines of goods have found it impossible or unpracticable to make the radical changes necessary to enable them to market a product. As a result of these conditions, the industry has been passing through a transition stage, into a more flexible and adaptable form than it has ever had in the past.

In an industry so long established as textile manufacturing there are seldom, if ever, any radical developments that mature within a single year. The progress for 1925 has thus been principally the continued growth of movements that have been under way for several years. The principal features and trends which are of especial interest for the engineer have been summarized briefly in the following paragraphs under group headings.

Materials. The one outstanding feature of the year has been the enormous growth of the manufacture and use of rayon or artificial silk. The following table shows the comparative consumption of artificial silk and natural silk in this country during recent years, the former being based on the *Textile World's* estimates and the latter on import figures of Department of Commerce. The probable production of artificial silk in 1925 is also given. The year 1911 is included for comparison, as that was the beginning of artificial-silk manufacture in the United States.

From these figures it is evident that the production of this artificial fiber may shortly surpass the present consumption of natural silk.

The extensive use of rayon combined in fabrics with cotton or wool has necessitated much modification in dyeing and finishing processes, as well as extensive adaptation of existing machinery to handle the combination material satisfactorily.

TABLE 1 ARTIFICIAL SILK VS. RAW SILK

Year	Artificial-silk production, lb.	Raw-silk imports, lb.
1925	48,000,000[1]	...
1924	38,850,000	44,868,465[1]
1923	35,490,000	49,505,581
1922	26,000,000	50,711,826
1921	18,000,000	45,355,095
1920	9,000,000	30,058,374
1911	320,000	20,904,703

Estimated. [1] For 11 months ending November.

Continued substitution of lower-grade fibers of all kinds for raw material of higher grade and cost also has remained a marked tendency, necessitating many changes in machine equipment.

In addition to the widespread interest and activity in rayon, further commercial developments have also been made in other important fibers, notably rhea, ramie, flax, and artificial wool. These developments have been regarded by most manufacturers with interest and open mindedness.

Machinery. Among the principal machinery developments are:

- *a* Adaptation of existing machinery for processing new or lower-grade fibers.
- *b* Tendency toward refinement in design and construction of all textile machinery.
- *c* Trend toward standardization of textile machinery.
- *d* Arrangement of machinery in sequence or "range" wherever processes permit. This has been particularly marked in finishing equipment where variable and automatic speed control is an essential element.
- *e* Development of drying equipment for higher production speeds than has been practicable with dry cans.
- *f* Application of centralized control of lubrication on heavy machinery such as calenders.
- *g* Improved equipment for mixing and blending of different kinds of raw stock.
- *h* Development of improved clutches for machine drives.

Mill Construction. While comparatively few large mills have been built during the year, the aggregate amount of construction comprising plant additions and alterations further indicates the extent of the industry.

There appears to be a trend toward increased use of structural-steel framing for mill buildings, with brick walls and plank floors. This type of building is more adaptable than the concrete mill, and also may be constructed in less time and at somewhat less cost.

The tendency toward increased length of spans still continues, thus permitting more flexibility in machinery arrangement.

Materials Handling. Much progress has been made in extending the application of modern materials-handling equipment in all departments of the mill, and this is a most promising field for further development.

Power. The cost of power, being the third largest item of manufacturing expense, deserves the best efforts of the power engineer. Among the more recent features in this field are the following:

- *a* Extended application of the individual motor drive to practically all textile machines.
- *b* Further development of automatic variable-speed control for motor-driven machines in "range," as well as variable-speed alternating-current motors.
- *c* Increased use of purchased power and interconnection of mill plants with public-service systems.
- *d* Revision of obsolete water powers with high-efficiency wheels.
- *e* Re-equipment of mill boiler plants with larger boiler units and improved combustion equipment.
- *f* Application of pulverized-coal-burning equipment in some of the larger textile plants.
- *g* Owing to the relatively low price of coal as compared with fuel oil, many plants have abandoned the use of the latter fuel and have installed coal-burning equipment.
- *h* Close study of heat-using processes and extended application of temperature-control equipment.

The distribution of primary power in the entire industry, based on census figures for 1914 and 1919—the latest available—is shown in Tables 2 and 3.

TABLE 2 DISTRIBUTION OF PRIMARY POWER IN THE TEXTILE INDUSTRIES, 1914 CENSUS

Industry	Total primary, 1000 hp.	Steam power, 1000 hp.	Water power, 1000 hp.	Internal-combustion engines, 1000 hp.	Rented power: Elec., 1000 hp.	Rented power: Other, 1000 hp.
Carpets and rugs	44.0	29.5	4.1	...	9.2	1.2
Cordage, jute, twine, and linen	93.9	65.8	14.4	2.8	10.7	0.2
Cotton goods	1585.9	1011.3	314.2	4.0	252.9	3.5
Dyeing and finishing	130.1	111.5	9.9	0.7	7.2	0.8
Hosiery and knit goods	125.7	80.8	14.6	1.1	26.3	2.9
Silk goods	117.0	78.3	7.6	1.8	23.8	5.5
Woolen, worsted, and felt	398.4	288.7	76.3	2.7	25.0	5.7
Total	2495.0	1665.9	441.1	13.1	355.1	19.8
Per cent of total	100.0	66.8	17.7	0.5	14.2	0.8

TABLE 3 DISTRIBUTION OF PRIMARY POWER IN THE TEXTILE INDUSTRIES, 1919 CENSUS

Industry	Total primary, 1000 hp.	Steam power, 1000 hp.	Water power, 1000 hp.	Purchased power, 1000 hp.
Cotton goods	1856.5	1025.7	307.1	523.7
Woolen and worsted	521.0	352.4	81.1	87.5
Knit goods	148.6	76.0	12.9	59.7
Silk goods	171.7	88.2	8.3	75.2
Dyeing and finishing	157.7	118.2	13.5	26.0
Cordage and twine	103.9	58.3	18.8	26.8
Total	2959.4	1718.8	441.7	798.9
Per cent of total	100	58	15	27

Standardization. In coöperation with the Division of Simplified Practice of the Department of Commerce, considerable progress has been made in reducing the number of weights and sizes in certain lines of textiles as follows:

The number of widths and weights of duck and sail cloth has been cut from 460 to 94.

The number of sizes of bed blankets has reduced from 78 to 12.

More work of this character is in progress.

Research. It is an outstanding fact of the year that manufacturers as a whole are more receptive to the introduction of new methods and ideas than ever before. The results obtained in many plants by careful study and application of improved methods of processing and distribution with resultant labor extension have clearly shown the importance of such practical research.

Management. There have been some developments along the lines of coöperative management with employees' representation in the control, and these are being carefully observed.

Wages have been subject to downward revision in some sections without labor disturbances of consequence.

More direct relations have been established between the mills and the retailers and thus to the purchasing public, with mutual benefit to all.

The Textile Division of the Society should participate more actively in the continued development of this industry and desires the full coöperation of all members and closer relationship with the various associations of textile manufacturers to this end.

This enormous industry with its many branches and allied lines of manufacture, presents a wide field of activity and opportunity for the mechanical engineer.

The varied problems of the industry are becoming more and more complex and are demanding technical talent of the highest order for their solution.

The future progress of this old industry will unquestionably be determined to a large extent by the contributions of the engineer, not only in the development and improvement of machinery and processes but also in the organization of production along more efficient lines.

GEO. H. PERKINS, *Chairman.*

International Critical Tables Soon to Be Published

THE National Academy of Sciences and the National Research Council will shortly announce the forthcoming publication of International Critical Tables of Numerical Data of Physics, Chemistry, and Technology.

The material contained in International Critical Tables has been collected and critically evaluated by some 300 coöperating experts, including chemists, physicists, and engineers of the United States, Canada, Great Britain, Belgium, France, Italy, Austria, Germany, Denmark, Switzerland, Holland, Australia, and Japan.

The scope of the material collected covers all available information of value concerning the physical properties and numerical characteristics of (*a*) pure substances, (*b*) mixtures of definite composition, (*c*) the important classes of industrial materials, (*d*) many natural materials and products, and (*e*) selected data for selected bodies or systems, such as the earth and its main physical subdivisions, and the solar and stellar systems. Publications of the world in all languages have been combed for data, and much unpublished information has also been collected.

In making the publication contract, the National Research Council has reserved to members of scientific and engineering societies, and to libraries and research laboratories, for a certain period, the right to purchase the volumes at the estimated manufacturing cost.

International Critical Tables will be issued as a set of five volumes comprising an estimated total of 2500 pages $8^1/_2 \times 11$ inches. The subscription price of the Tables up to the appearance of Volume I, early in 1926, will be $35 to members of contributing societies, of which the A.S.M.E. is one. After the appearance of Volume I the work will be placed on the market by the publishers at their regular price of $60 for the set of five volumes.

Those desiring to place an advance order for a set of these International Critical Tables at the low prepublication price are advised to communicate directly with the National Research Council, Washington, D. C.

Fuel-Injection-Engine Research by the National Advisory Committee for Aeronautics

THE National Advisory Committee for Aeronautics is undertaking at its laboratories at Langley Field, Va., research work on various problems bearing on the application of compression-ignition heavy-oil-engine principles to comparatively small-size but high-speed engines with a view to determining the feasibility of, or aiding in, the utilization of such engines in aeronautic service. The Diesel engine has attractive possibilities for this purpose because of its inherent low fuel consumption and its ability to use relatively cheap and safe fuels.

The conditions in the high-speed compression-ignition engine are so different from those existing in commercial engines now in use that experiences with the latter engines can serve only as a very rough guide. For this reason coördinated study of a number of the more fundamental problems is desirable to avoid protracted haphazard experimentation.

The preparation of the fuel for ignition and for its actual combustion in the short time available is probably the most outstanding problem in the high-speed-engine application. Systematic studies are being made, therefore, to determine the effect of the pressure in the combustion chamber and the pressure of the injected fuel upon the rate of penetration of different types of fuel jets. Series pictures of a number of actual jets taken by special high-speed photographic apparatus at the rate of 5000 exposures per second forms a basis for this study. Investigations of the influence of different types of fuel nozzles upon the character of the spray produced are made with this and other apparatus. Some indication of the influence of the degree of atomization on the penetration is also obtained.

The effect of compression pressure upon the lag of ignition, when a number of different types of fuel sprays are used, is determined by means of a special laboratory engine arranged for quick change of the compression pressure. The effects of changes of compression pressure upon power, specific fuel consumption, and maximum pressure are studied with this engine. In this way favorable compression pressure and favorable types of fuel sprays are determined.

In order to obtain the high capacity that especially characterizes the present aeronautic engine, every effort must be made to utilize practically all of the air in the combustion of the fuel. Since turbulence is probably the most favorable means of accomplishing this, independent studies of the influence of combustion chamber form on turbulence, in combination with a number of different types of fuel sprays, are made in the laboratory on a single-cylinder engine.

Other specific problems are attacked in a similar manner, so that when considered in light of the whole problem, a basis for rational study is formed.

Metallurgical Developments in the Valve and Fitting Industry

By V. T. MALCOLM,[1] INDIAN ORCHARD, MASS.

A FEW years ago pressures exceeding 250 lb. and temperatures over 500 deg. fahr. were unknown in industrial practice, but with the advent of better and more uniform materials we are now able to use pressures of 600 lb. and temperatures of 800 deg. fahr. in some power plants, and pressures of 600 lb. with temperatures of 950 deg. fahr. in oil refineries.

Materials for high-pressure and high-temperature service should have such properties as resistance to oxidation and corrosion, and should maintain certain physical properties at high temperatures.

It is the purpose of this paper to discuss the development of materials for high-pressure and high-temperature service and to call attention to the research work carried on in this field.

Development of Cast Alloy Steels Suitable for Valves and Fittings

With the use of high pressures and elevated temperatures in the modern power plant and oil refinery, it has been found necessary to develop a cast alloy steel suitable for valves and fittings in this class of work, and with properties far superior to those of ordinary cast steel.

In the development of this cast alloy steel the most marked advances have undoubtedly been in the electrical production of the metal, and in the extension of our knowledge of the principles of proper melting and heat treatment.

The cast alloy steel now used in valves and fittings has a fine, dense structure and that quality so often described as "tough hardness," which insures greatly increased resistance to fatigue, shock, and erosion.

As regards seating materials for valves operating at high temperatures, research has led to the development of "Davis Metal,"[2] a material with high physical properties at elevated temperatures, together with a coefficient of expansion approximately equal to that of the steel with which it is associated.

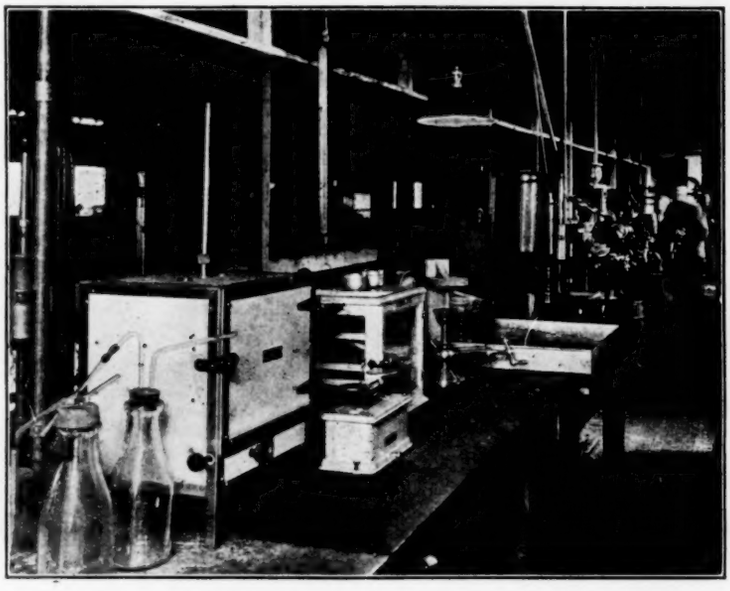

Fig. 1 Photograph of a Sand-Testing Laboratory, Showing Apparatus for Moisture, Strength, and Permeability Determination

Improvement in Testing Methods Necessitated by Use of High-Temperature Metals

Just as ordinary cast steel met the requirements of power plants several years ago, so did the ordinary tensile test suffice for the acceptance of steel castings. With the advent of high-temperature metals, however, a closer study had to be made of such properties of the metals as resistance to shock, endurance limit, hardness and machinability, toughness, and wearing qualities, resistance to corrosion and erosion, and finally ability to withstand constant pressure at elevated temperature without distortion or failure. Testing technic has been greatly improved and extended along lines now familiar to engineers, and some special methods of testing deserve particular mention.

Impact Testing

This method of testing steels is considered to be one of the most important of the mechanical tests, as it affords a reliable indication of the resistance to deformation, i.e., of hardness and tensile strength; and also when cohesion is small in relation to the internal frictional resistance to distortion of the cohesive strength. In the author's laboratory an impact machine of the Charpy type is used, where complete investigation is under way to determine the shock resistance of metals at hand.

Endurance Testing

The ratio of the bend endurance limit to the tensile strength of a metal may be called the "endurance ratio," or, more specifically, the "bend-tension static endurance ratio." According to McAdam[1] and others, the ratio for steel is between 0.35 and 0.55, with an average of about 0.50.

Endurance- or fatigue-testing machines are mostly of two forms, the beam type and the cantilever type. In the laboratory with which the author is associated the Farmer beam type as modified by Professor Moore[2] is employed. In this machine the test piece is freely supported at the ends on two sets of ball bearings and loaded through two others, each $1\frac{1}{2}$ in. from the center of the test piece. Two equal loads are hung from springs attached to collars which encircle the outer races of the two middle bearings.

The specimen is rotated through the loose coupling at one end and the revolutions counted by a suitable counter geared to a worm on the other end of the specimen. When failure occurs, the specimen will stop rotating because it "binds," and the belt from the motor will either slip or be thrown off.

Endurance or fatigue tests are made on these machines by taking a number of test pieces, beginning with a stress of about one-half the tensile strength of the metal, and testing to destruction. The number of stress cycles necessary to bring about fracture is recorded by the counter. The stress is somewhat reduced on successive tests until a total of 20×10^6 cycles is obtained without fracture.

This test is very desirable for determining the endurance properties of steel and non-ferrous alloys used for bolts and spindles in valves and fittings for high-pressure, elevated-temperature service.

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[1] Metallurgical Engineer, Chapman Valve Mfg. Co.

[2] V. T. Malcolm, Davis Metal. Serial Report of the Prime Movers' Committee on Higher Steam Pressures and Temperatures, June, 1924, pp. 19 to 22.

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[1] D. J. McAdam, Jr., Correllation of Endurance Properties of Metals. Trans. A.S.S.T., vol. 6, no. 3, 1924.

J. M. Lessells, The Elastic Limit in Tension and Its Influence on the Breakdown by Fatigue. Inst. Mech. Engrs. (London), December, 1924.

[2] H. F. Moore and J. B. Kommers, An Investigation of the Fatigue of Metals. Bulletin 124, University of Illinois.

RADIOGRAPHY

Radiography,[1] or the testing of metals by use of the X-ray, is one of the most recent methods used in the testing of high-pressure, high-temperature valves and fittings. A number of excellent papers[2] have recently increased the interest in this valuable type of test. The use of radiography together with metallography facilitates the location and study of the cause of defects in steels and the application of the necessary corrective measures.

The company with which the author is connected has great faith in what radiography has done and will do to insure the integrity of castings, but it must be realized that radiography is in its infancy and while rapid progress will undoubtedly be made, one thing of great importance is to be remembered and that is that the examiner of radiographs must be skilled in foundry technic and thoroughly capable of distinguishing between blemishes and real defects.

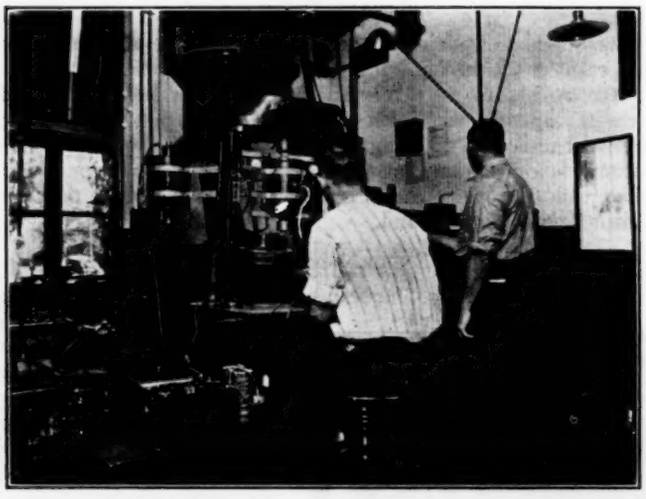


FIG. 2 PHOTOGRAPH OF APPARATUS USED FOR SHORT-TIME HIGH-TEMPERATURE TESTING, SHOWING THE FURNACES, EXTENSOMETERS, POTENTIOMETER, TRANSFORMER, AND TESTING MACHINE

SAND TESTING

One of the most important problems that confront the manufacturers of quality steel castings is the character of the sand used in the molds and cores; for it is just as necessary to control the quality and conditioning of the sand as it is to control the metal, if sound castings are to be obtained.[3]

With a complete sand-testing laboratory, it is possible to determine:

1 The amount of moisture in the sand, and to make any necessary corrections to it before it is used in making molds
2 The actual resistance of the sand to gases, and to establish the correct permeability for sand, so as to allow gases generated to pass off freely during the casting operation
3 The actual strength of sand, so that the molds will be sufficiently strong to withstand the pressure of the hot metal without breaking during the casting
4 The refractoriness and durability of the sand, so as to enable it to withstand the hot metal without forming slag, which might enter into the steel.

With strict adherence to certain standards, casting losses from this source may be reduced to a minimum.

SHORT-TIME TESTS AT HIGH TEMPERATURES

Very little need be said regarding the methods of testing metals at elevated temperatures over short periods, such methods having been described in the transactions of various engineering societies,[1] and the latest information to be gathered together on this subject given in the report of the Cleveland Symposium.

However, it might be well to state that the apparatus used in this laboratory is standard equipment and a part of the testing machine, so that it may be swung into place whenever needed.

LONG-TIME TESTS AT ELEVATED TEMPERATURES

The author has previously pointed out that in some cases failure only occurs after a lapse of time,[2] due to flow of metal, although such metals had shown good results when tested in a short time at the same temperature. Tests of short duration carried out on metals are not always sufficient to indicate the behavior of a metal in service. The author believes, therefore, that a knowledge of the behavior of metals at elevated temperatures over long periods would undoubtedly be of great technical importance. Tests made by Dickenson[3] and by Lea[4] have cast grave doubts on our ideas of yield point and elastic limit of certain metals at high temperatures.

The Westinghouse Company,[5] The Bureau of Standards,[6] and the Chapman Valve Manufacturing Company have each undertaken systematic research on the effect of temperature on the properties of metals over periods of long duration. The work of both the Westinghouse Company and the Bureau of Standards has been on rolled steel and bronze, while the work of the Chapman Company has been on cast carbon and alloy steels.

The apparatus used in this laboratory in carrying out these tests consists of electrically heated horizontal furnaces in which the test bars are placed, the bars being screwed into adapters attached to cables, one of which passes over a drum. An 18-in. wheel carries the other cable which suspends a load, making the entire system in one horizontal line. The temperature control is vested in an automatic controller, which keeps the temperature of the furnace constant during the duration of the test.

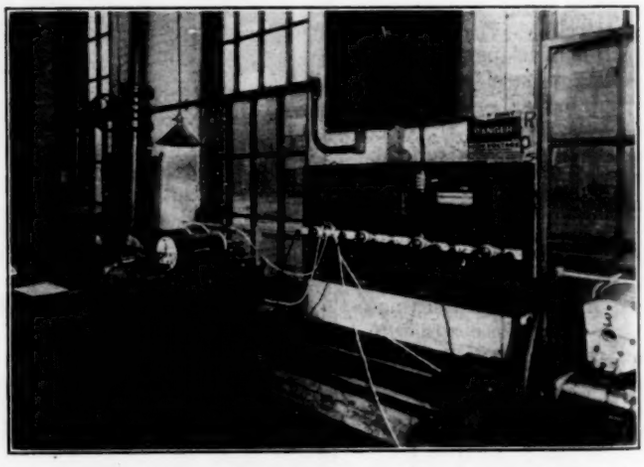


FIG. 3 PHOTOGRAPH OF LONG-TIME HIGH-TEMPERATURE TESTING APPARATUS, SHOWING FURNACES, AUTOMATIC CONTROL, PYROMETER, TESTING MACHINES, AND MEASURING MICROMETER MICROSCOPE

The sides of furnaces are slotted and fitted with doors, through which the "creep" of specimen is measured with a micrometer microscope graduated to 0.01 mm., so that very small movements in the steel under test may be determined.

---

[1] Report of Committee on Metallography, A.S.T.M. Convention, June, 1925.
V. T. Malcolm, Radiography, A.S.T.M. Convention, June, 1925.

[2] I. E. Moultrop and E. W. Norris, X-Ray Examination of Steel Castings. MECHANICAL ENGINEERING, vol. 47, May, 1925, p. 393.
H. H. Lester, X-Ray Tests Applied to Problems of the Steel Foundry. Trans. A.S.S.T., vol. 6, no. 5, 1924.

[3] Trans. A.F.A., vol. 32, part 2, entire volume.

[1] V. T. Malcolm. Trans. A.S.M.E., vol. 44, p. 1174; Proc. Nat. Elec. Lt. Assn., vol. 80, 1923; Physical Properties of Metals at Elevated Temperatures, Trans. A.S.S.T., vol. 5, no. 3, 1924; Trans. A.S.M.E., vol. 46, 1924; Proc. A.S.T.M., vol. 24, 1924; *Power*, June 24, 1924.

[2] V. T. Malcolm, Methods of Testing at Various Temperatures and their Limitations. Trans. A.S.M.E., vol. 46, 1924, pp. 394 and 397.

[3] J. H. Dickenson, Some Experiments on Flow of Steels at Red Heat. *Jl. Iron & Steel Institute* (London), vol. 106.

[4] F. C. Lea, Effect of High and Low Temperature on Materials. Inst. Mech. Engrs., London, December 5–18, 1924.

[5] Lynch, Mochel, and McVetty, The Tensile Properties of Metals at High Temperature. A.S.T.M. Convention, June, 1925.

[6] H. J. French, Discussion on Properties of Metals at Elevated Temperatures over Periods of Long Duration. A.S.T.M. Convention, June, 1925.

The author has duplicated the findings of Mr. French of the Bureau of Standards and quotes the following from Mr. French's discussion of Professor Jasper's paper.[1]

The total flow producing fracture when steel is subjected to a fixed total load, in tension at approximately constant temperature, takes place in three distinct steps, the importance of which may vary with applied load and temperature.

The three stages of flow are:

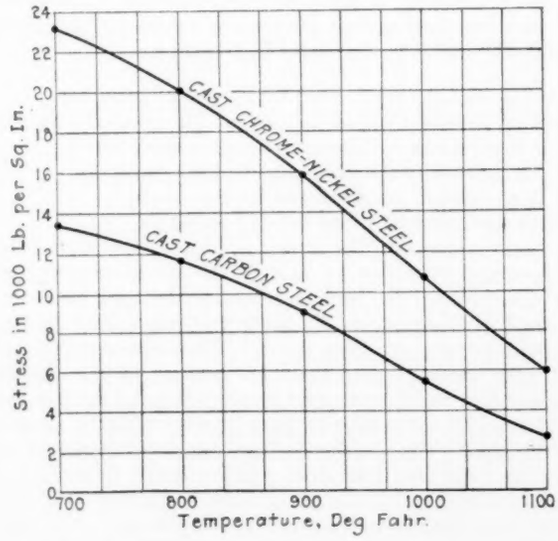


FIG. 4 MAXIMUM ALLOWABLE STRESSES FOR LONG-DURATION TESTS ON CAST CHROME-NICKEL STEEL AND CAST CARBON STEEL

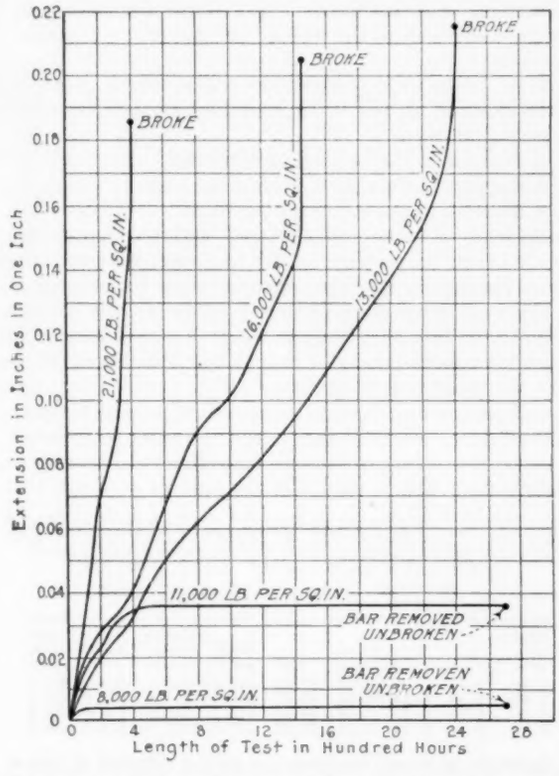


FIG. 5 RESULTS OF LONG-DURATION TESTS ON CAST CHROME-NICKEL STEEL, SHOWING LIFE UNDER SUSTAINED LOADS AT 1000 DEG. FAHR. CONSTANT TEMPERATURE

1 An initial flow

2 A secondary flow at a fairly constant rate, which is also considered less than the rate during the first and third periods

3 A final rapid flow just before fracture.

As constant applied load is increased, the initial flow and rate of flow in second period increases and the life of the steel decreases. The final rapid flow begins when the reduction in cross-section, accompanied by appreciable elongation, has raised the unit stress to a definite value at each temperature.

The author believes that at each temperature there is a particular stress below which the metal may flow (that is, the first period), and that it continues to deform under continuously applied stress, but with time the flow will drop to zero and continue there, (second period). Above this stress the metal will flow rapidly till final fracture (third period).

The author finds that for each temperature of the steel tested there is at this temperature a stress which if exceeded will cause continuous flow, and finally failure, though valves and fittings operating at this temperature may last for long periods. It was therefore necessary in his researches to determine the stress at each temperature that could be applied to cast steel without causing appreciable flow or deformation.

Much of this work has been completed, and from the results obtained he is certain that cast alloy steel will stand the severe service of 1000 deg. fahr. without deformation over long periods, provided the allowable stress is not exceeded.

It has been shown that if the temperature is increased from 700 deg. fahr. to 1000 deg. fahr. a gain of 20 per cent will be made in the operation of power plants. The only reason for not adopting the higher temperatures has been the lack of information with regard to the ability of metals to withstand them over long periods.

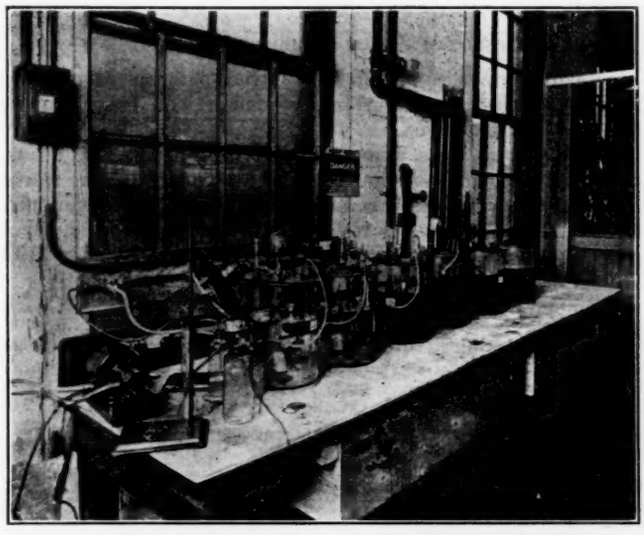


FIG. 6 PHOTOGRAPH OF CORROSION-TESTING LABORATORY, SHOWING BATTERY OF CORROSION-TESTING APPARATUS IN PLACE

CORROSION TESTING

During the past few years the corrosion problem has been one of the actively exploited fields of metallurgy.

The ultimate aim of all corrosion tests should be to devise a comprehensive series of tests to which standard specimens of material may be subjected, and by which the rate of corrosion of these metals may be predicted for certain service conditions.

One of the most important though somewhat neglected studies of the corrosion problem is the action of various gases at temperature higher than ordinary. Therefore, in the study of corrosion we have two conditions to consider, namely, "erosion," which is the disintegration on the destructive action by physical causes, and "corrosion," which is the disintegration or destructive action by chemical causes.

Little is really known about the mechanism and true nature of corrosion, and so much depends upon the kind of reaction produced that it is hard to predict what will happen after a valve has been in service a month, based on ordinary immersion tests.

In the research work with which the author has been associated, efforts have been made to overcome difficulties in determining true corrosion by using apparatus designed as nearly as possible to duplicate service conditions, and by noting the character of film, pitting, etc., and reducing the work to inches penetration per month, so that an ultimate figure might be obtained determining the life in service of valves handling corrosive solutions.

[1] T. M. Jasper, Typical Static and Fatigue Tests on Steel at Elevated Temperatures. A.S.T.M. Convention, June, 1925.

Steam Bleeding and Turbine Performance

Results of Tests Showing the Effect of Steam Bleeding on Total Power-Plant Efficiency, also the Effect of Changes in Vacuum and Superheat on Turbine and Condenser Performance

By C. D. ZIMMERMAN,[1] CLEVELAND, OHIO

THE test data outlined in the following are divided into two parts, the first of which is concerned with the net effect on steam-power-plant efficiency of single-stage steam bleeding, and the second with the characteristics of steam-turbine performance as affected by changes in condenser vacuum and steam superheat. The second part of the paper is a necessary supplement, since a change in the steam bleeding is followed by changes in superheat and condenser vacuum.

It is worthy of note that the condenser back pressure was sufficiently low to indicate the economical vacuum for loads above 25,000 kw. To furnish data for a complete study of turbine performance, additional test results are included in the second part of the paper which have no direct bearing on the subject of steam bleeding.

I—Effect of Steam Bleeding on Efficiency

In addition to the net effect on steam-power-plant efficiency, the detailed changes on turbine, condenser, and boiler unit performances are also given.

The boiler-unit tests were mainly concerned with the changes brought about by changes in feedwater temperature. The relation of the efficiency to the rate of driving of the boiler equipment was determined in previous tests, which were given by John Wolff in a paper published in Mechanical Engineering for January, 1925. This curve is shown in Fig. 10.

A summary of the equipment is as follows:

Boilers, duplex Stirling, sq. ft. 30,600
Superheaters, B. & W. convection type, sq. ft. 4,520
Water-tube screen, sq. ft. 835
Economizers, Power Specialty Co., sq. ft. 22,080
Furnace volume above screen, cu. ft. 26,000
Turbine, General Electric Co., single-cylinder, 17-stage, 30,000-kw., bleeding at 13th stage.
Throttle pressure, lb. per sq. in., gage 235
Steam superheat, deg. fahr. 250
Generator, General Electric Co., type A.T.B.-4-30,000; capacity, 30,000 kw.; at 85 per cent power factor, 35,300 kva.
R.p.m. 1,800
Voltage 11,430
Ventilation, closed air system, General Electric fin-type cooler, condensate water, two-pass.
Exciter, direct-connected, capacity 210 kw. at 250 volts.
Condenser, Worthington Pump and Machinery Corp., surface, sq. ft. 53,000
Bleeder heater, Ross Heater and Manufacturing Co., sq. ft. 985
Turbine and Condenser Auxiliaries:
- Circulating-water pumps, two per unit, Worthington Pump and Machinery Corp.
- Circulating-water pump drive, one General Electric Curtis steam turbine, 200-hp.; one General Electric induction motor, 200 hp.
- Steam-jet vacuum pump, Worthington Pump and Machinery Corp., size, 3.20 cu. ft.
- Hurling-water pump, Worthington Pump and Machinery Corp., size, 8. C. L., motor drive, General Electric induction motor, 75 hp.
- Condensate pumps, two per unit, Worthington Pump and Machinery Corp., size 6.
- Condensate-pump drive, one General Electric Curtis steam turbine, 60 hp., one General Electric induction motor, 60 hp.

Method of Testing

To determine the effect of steam bleeding on the turbine characteristics, the turbine was tested at loads of 15,000, 20,000, 25,000, and 30,000 kw. with steam bleeding ranging from zero to the maximum. The steam bled was calculated from a heat balance on the bleeder heater. A similar method was used to determine the turbine characteristics under variable vacuum and superheat conditions with no bleeding.

To relate bleeding to the boiler-unit efficiency, the boiler was tested at a constant rate of driving and excess air, at about 100, 150, and 200 deg. fahr. feedwater temperatures.

Results

Effect on Turbine-Unit Performance. The results of an increase in steam bleeding for a constant generator output were:

1 An increase in the steam input to the turbine
2 A decrease in the condenser back pressure
3 An increase in the feedwater temperature.

The total water rate, as shown in Fig. 1, increases when the last stages are by-passed by part of the steam, although this is partly compensated for by a decrease in the back pressure. As shown in Figs. 2 and 3, as the amount of steam bled is increased the amount of exhaust-steam input to the condenser and the condenser back pressure decrease. An analysis of the test results shows that the moisture content of the steam in the last stage is affected more by the condenser back pressure than by the amount of steam bled. The condenser back pressure decreased as the amount of steam bled increased, which resulted in an increase in the moisture content of the steam in the last stage. Fig. 4 shows the change in absolute pressure at the outlet of the 13th stage with different loads and amounts of steam bled, while Fig. 5 shows the heat transfer in the bleeder heater as a function of the steam bled. Fig. 6 shows the increase in feedwater temperature with an increase in the amount of steam bled. Fig. 7 shows the change in B.t.u. per kw-hr. chargeable to the turbine unit alone as a function of the steam bled.

Effect on Boiler-Unit Performance. The effects of an increase in steam bleeding on the boiler unit performance for a constant generator output were:

1 A decrease in the boiler-unit efficiency
2 A decrease in the rate of driving the boiler
3 A decrease in the steam temperature.

The decrease in boiler-unit efficiency with an increase in steam bled results from an increase in the feedwater temperature which causes an increase in the economizer exit gas temperature. Normally, this heat loss in the economizer will be slightly compensated for, because the rate of driving at which it is necessary to operate the boiler for a given generator output will decrease as the temperature of the feedwater is increased. Fig. 8 shows the change in boiler and economizer flue-gas temperature, steam temperatures, and unit efficiency with a change in the feedwater temperature, and Fig. 9 shows the change in the rate of driving the boiler for a given generator output with a change in the amount of steam bled.

TABLE 1 EFFECT OF STEAM BLEEDING ON TURBINE WATER RATE, FEED-WATER TEMPERATURE, SUPERHEATED-STEAM TEMPERATURE, BOILER RATE, BOILER AND ECONOMIZER EFFICIENCY, AND B.T.U. PER KW-HR. GROSS. LOAD 25,000 KW.

Steam bled per hr. lb.	Steam bled, per cent	Water rates, lb. per kw-hr.				Temperature, deg. fahr.			Boiler and econ. effy.	B.t.u. per kw-hr.
		Turbine	Aux. steam	Misc. steam	Total	Feed-water	Super-heated steam	Boiler rate		
0	0.00	9.71	0.24	0.34	10.29	113.2	668.7	180	90.5	14,392
7,000	2.69	9.83	0.24	0.34	10.41	143.4	663.4	177.7	90.2	14,225
14,000	5.30	9.98	0.24	0.34	10.56	172.7	657.0	176.0	89.8	14,115
20,000	7.48	10.11	0.24	0.34	10.69	197.1	651.3	175.3	89.5	14,021

The decrease in steam temperature as the amount of steam bled is increased is caused by both the decrease in the rate of driving the boiler and the increase in feedwater temperature. The decrease of steam temperature with a decrease in the rate of driving the boiler is a well-known characteristic of this type of superheater.

Effect on Total Plant Performance. The B.t.u. per kw-hr. shown in Table 1 is a gross value for a constant generator output and does not include losses incurred in normal varying-load conditions.

The last column in Table 1 was calculated[1] from the turbine-

[1] The method used in calculating is described in detail in an appendix to the complete paper.

[1] Production Engineer, Steam Department, Cleveland Electric Illuminating Company. Mem. A.S.M.E.

Contributed by the Power Division for presentation at the Annual Meeting, New York, November 30 to December 4, 1925, of The American Society of Mechanical Engineers. Abridged. All papers are subject to revision.

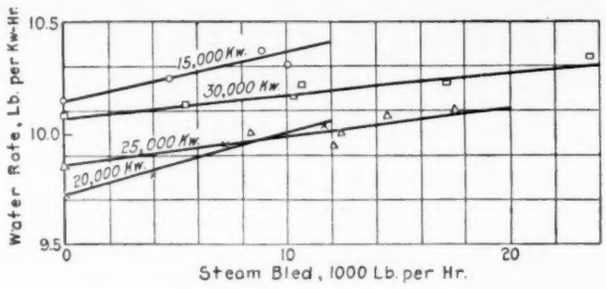


FIG. 1 EFFECT OF STEAM BLEEDING ON TURBINE WATER RATE
(Superheat, 250 deg. fahr.)

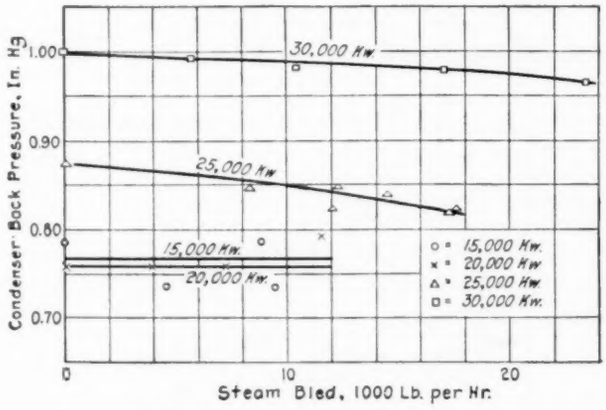


FIG. 2 EFFECT OF STEAM BLEEDING ON CONDENSER BACK PRESSURE

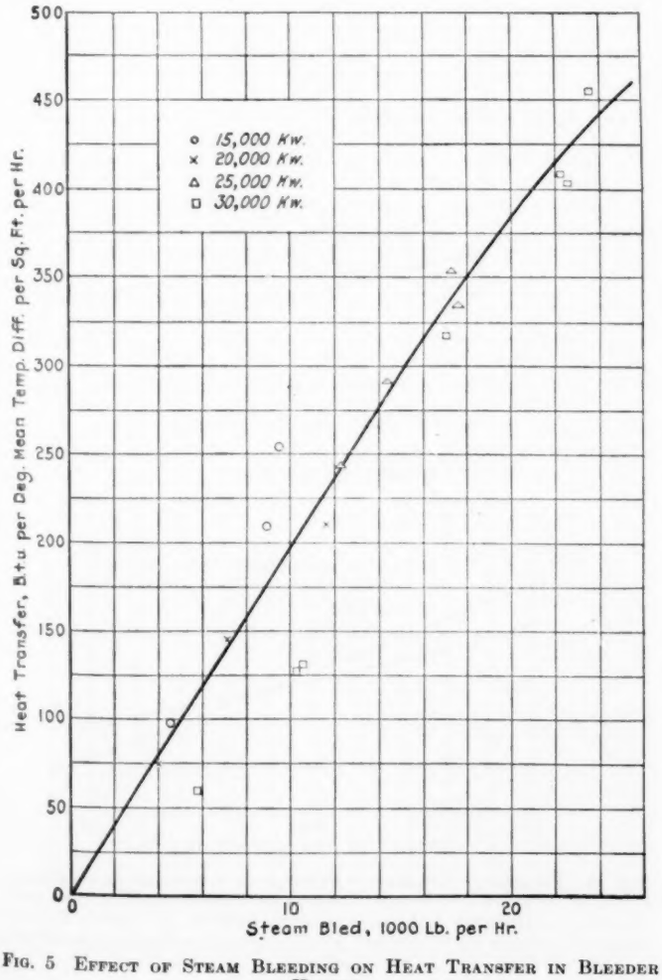


FIG. 5 EFFECT OF STEAM BLEEDING ON HEAT TRANSFER IN BLEEDER HEATER

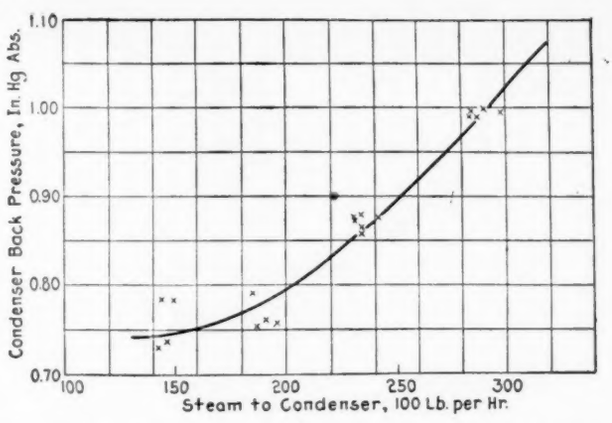


FIG. 3 EFFECT OF THE AMOUNT OF STEAM CONDENSED ON THE CONDENSER BACK PRESSURE
(Circulating-water temperature, 54.2 deg. fahr.)

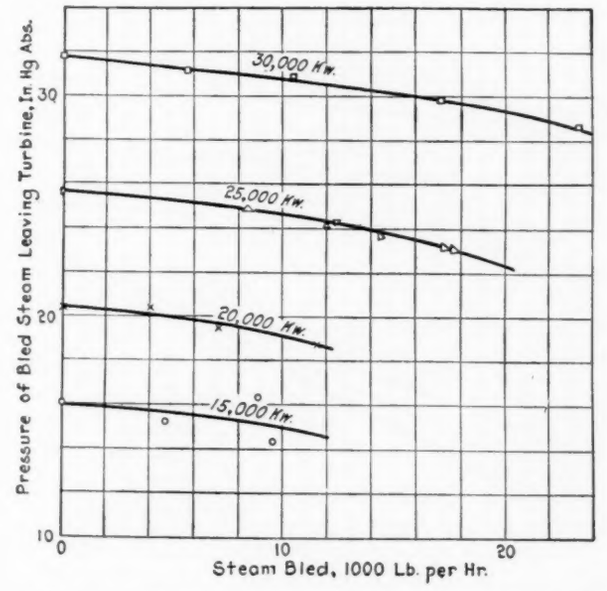


FIG. 4 EFFECT OF INCREASING STEAM BLED ON PRESSURE OF BLED STEAM LEAVING TURBINE

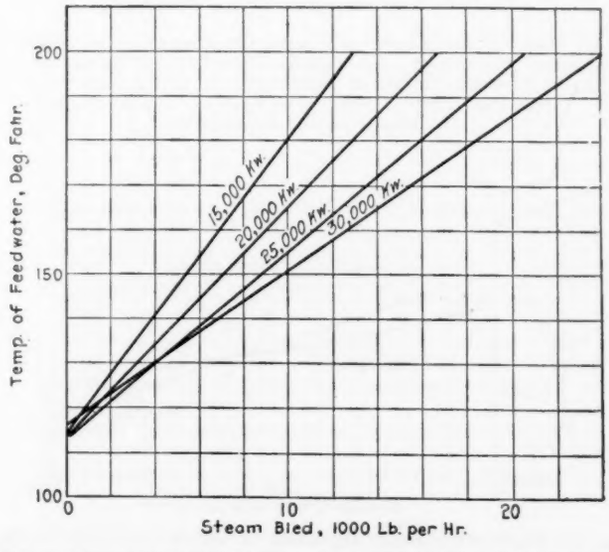


FIG. 6 EFFECT OF STEAM BLEEDING ON TEMPERATURE OF FEEDWATER
(These curves are representative of the actual operating cycle and include the temperature rise due to the steam auxiliaries.)

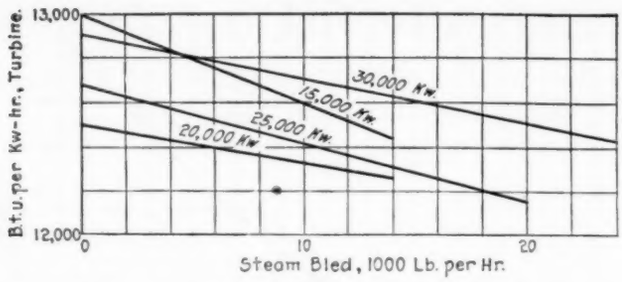


FIG. 7 EFFECT OF STEAM BLEEDING ON B.T.U. PER KW-HR. CHARGEABLE TO TURBINE UNIT ALONE

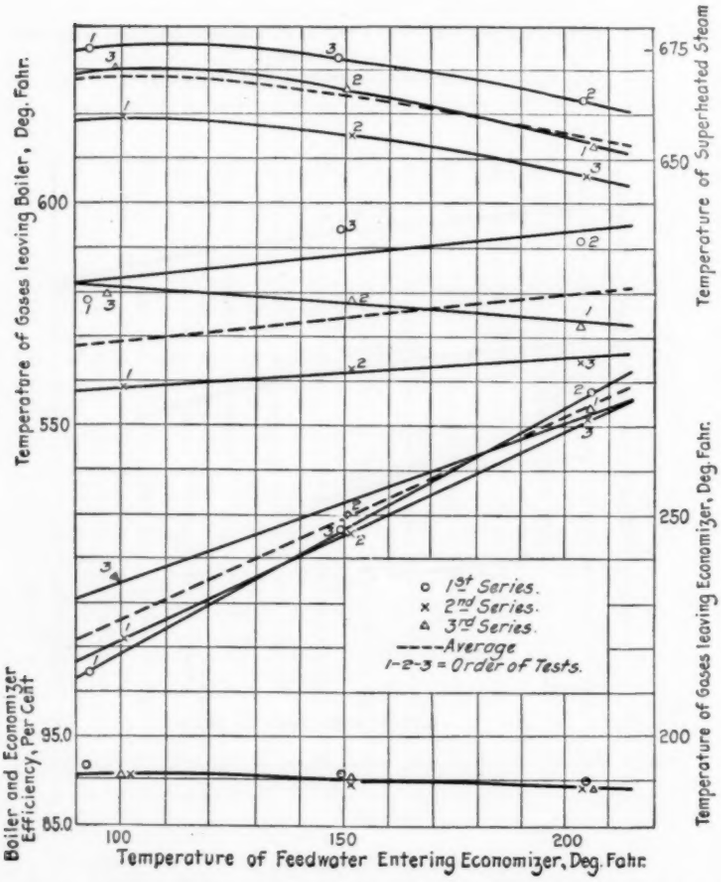


FIG. 8 EFFECT OF CHANGE IN FEEDWATER TEMPERATURE ON BOILER AND ECONOMIZER, EFFICIENCY, GAS TEMPERATURE LEAVING BOILER AND ECONOMIZER, AND SUPERHEATED-STEAM TEMPERATURE. TEST DATA CORRECTED TO 12.9 PER CENT CO_2 AND 180 PER CENT BOILER RATING
(Average per cent of rating, 180.)

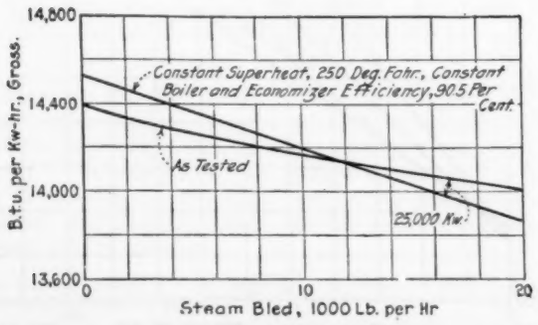


FIG. 13 EFFECTS OF STEAM BLEEDING ON GROSS B.T.U. PER KW-HR. BASED ON CONSTANT SUPERHEAT AND BOILER AND ECONOMIZER EFFICIENCY, COMPARED WITH RESULTS AS TESTED WHICH SHOWED THE CHANGES IN SUPERHEAT AND BOILER-UNIT EFFICIENCY GIVEN IN TABLE 1

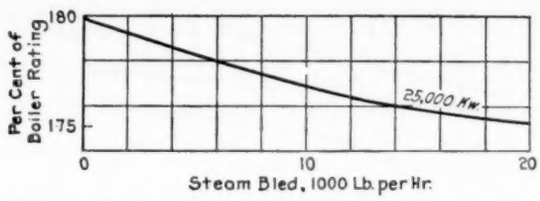


FIG. 9 EFFECT OF STEAM BLEEDING ON PER CENT OF BOILER RATING

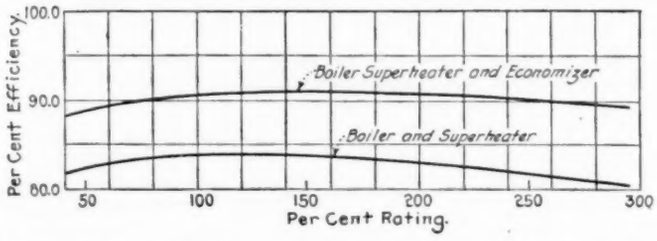


FIG. 10 EFFICIENCY-CAPACITY TESTS OF PULVERIZED-FUEL BOILER

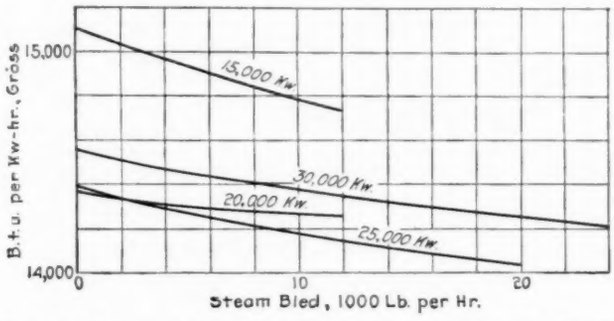


FIG. 11 EFFECT OF STEAM BLEEDING ON GROSS B.T.U. PER KW-HR.

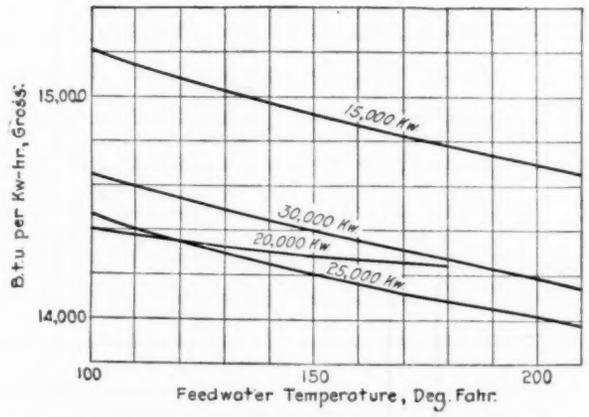


FIG. 12 EFFECT OF CHANGES IN FEEDWATER TEMPERATURE ON GROSS B.T.U. PER KW-HR.

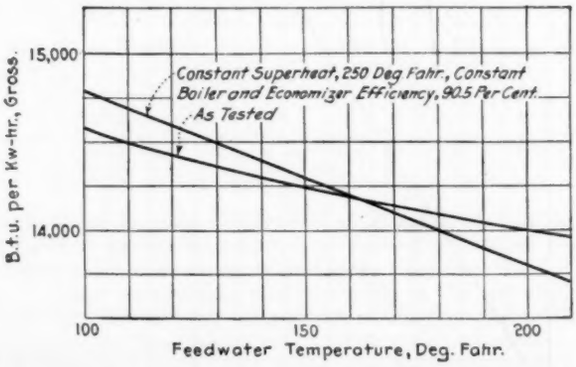


FIG. 14 EFFECTS OF CHANGES IN FEEDWATER TEMPERATURE ON GROSS B.T.U. PER KW-HR. BASED ON CONSTANT SUPERHEAT AND BOILER AND ECONOMIZER EFFICIENCY, COMPARED WITH RESULTS AS TESTED WHICH SHOWED CHANGES IN SUPERHEAT AND BOILER-UNIT EFFICIENCY GIVEN IN TABLE 1
(Load, 25,000 kw.)

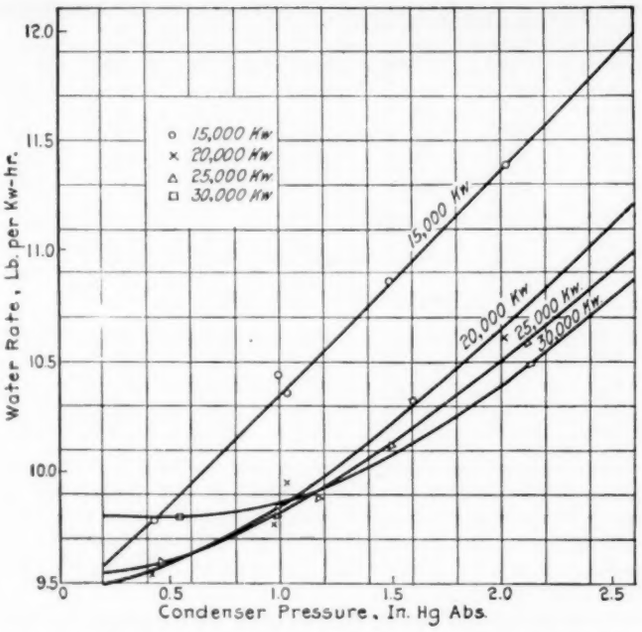


FIG. 15 EFFECT OF CONDENSER BACK PRESSURE ON TURBINE WATER RATE
(Steam pressure, 250 lb. per sq. in. abs.; superheat, 250 deg. fahr.)

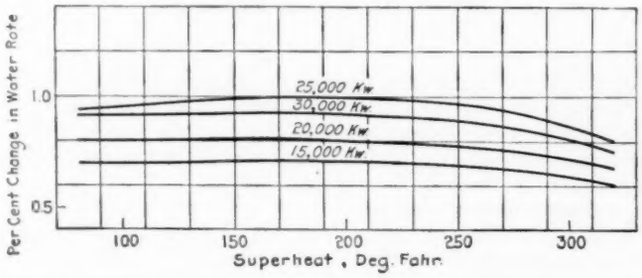


FIG. 17 PER CENT CHANGE IN WATER RATE FOR 10-DEGREE CHANGE IN SUPERHEAT
(Condenser pressure, 1 in. Hg abs.; steam pressure, 250 lb. abs.)

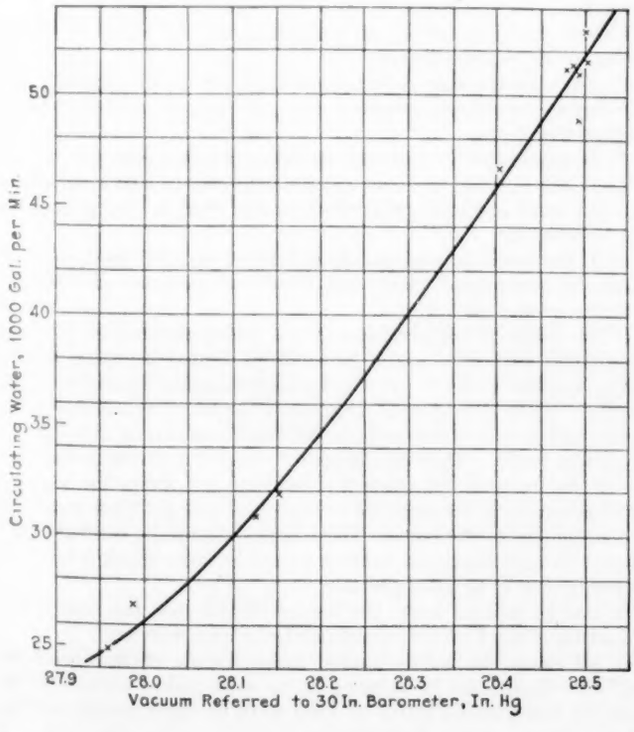


FIG. 20 EFFECT OF QUANTITY OF CIRCULATING WATER PUMPED ON CONDENSER VACUUM

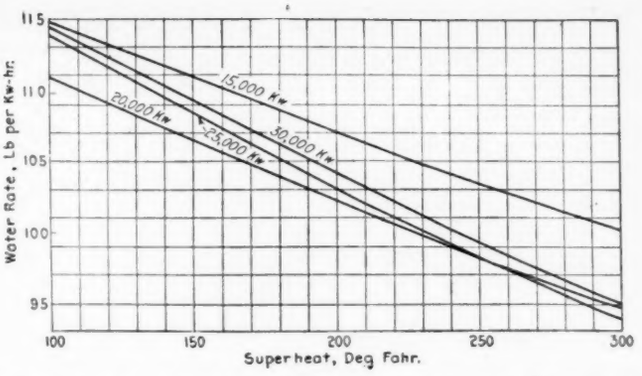


FIG. 16 EFFECT OF CHANGE IN SUPERHEAT ON TURBINE WATER RATE
(Initial steam pressure, 250 lb. per sq. in. abs.; condenser pressure, 1 in. Hg abs.)

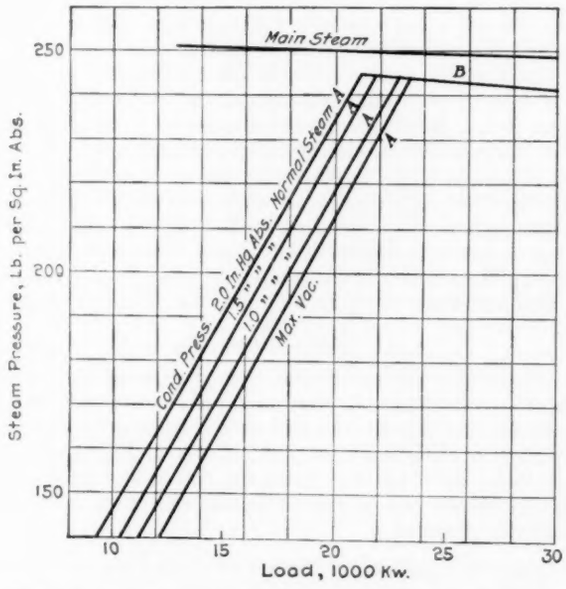


FIG. 18 EFFECT OF CONDENSER BACK PRESSURE ON TURBINE HEAD PRESSURE

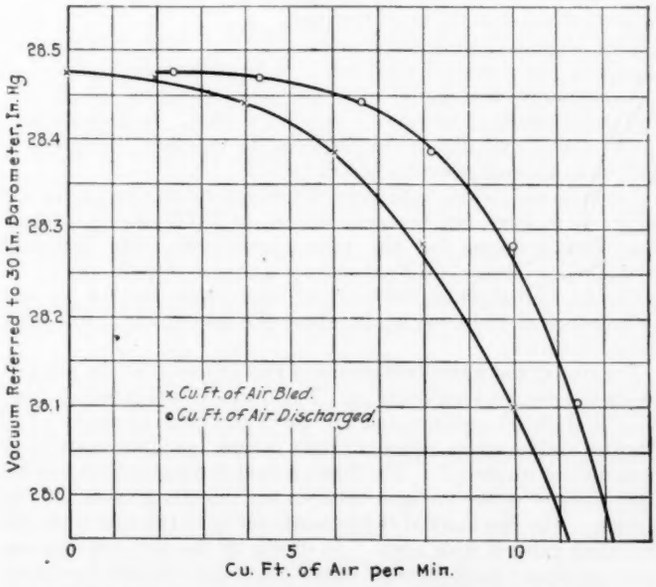


FIG. 19 EFFECT OF AIR IN CONDENSER ON CONDENSER VACUUM
(The air bled was measured as it entered the turbine exhaust casing. The air discharged was measured as discharged from the steam-jet air ejector. Load, 25,000 kw.)

TABLE 2 EFFECT OF CHANGE IN FEEDWATER TEMPERATURE ON BOILER AND ECONOMIZER EFFICIENCY, TEMPERATURE OF GAS LEAVING BOILER AND ECONOMIZER, AND TEMPERATURE OF SUPERHEATED STEAM

	Variable Feedwater-Temperature Tests								
Test number	986	1010	1005	988	1006	1009	987	1007	1008
Duration of test, hr	2	2	2	2	2	2	2	2	2
Total water evaporated, lb. per hr	157,218	164,334	165,579	165,496	169,417	167,569	169,196	177,701	176,270
Per cent boiler rating	176.0	183.8	185.5	176.9	182.6	180.3	174.1	184.8	183.1
Steam pressure, lb. per sq. in. gage	241.1	237.8	239.8	242.6	239.3	237.2	243.5	238.0	237.2
Steam temperature, deg. fahr	670.0	673.2	663.9	667.7	656.7	665.2	656.2	650.1	655.0
Superheat, deg. fahr	267.0	271.0	261.4	264.2	254.2	263.2	252.2	247.6	253.0
Temp. of feedwater entering economizer, deg. fahr	93.5	99.0	100.6	150.0	151.6	151.7	204.7	204.9	205.7
Temp. of feedwater leaving economizer, deg. fahr	232.4	235.3	228.0	281.8	267.4	274.2	316.0	302.3	306.2
Temp. rise through economizer, deg. fahr	138.9	136.3	127.4	131.8	115.8	122.5	111.3	97.4	100.5
Temp. of gases leaving boiler, deg. fahr	573	583	562	590	565	578	585	569	575
Temp. of gases leaving economizer, deg. fahr	211	238	226	242	247	251	272	275	276
Gas temp. drop through economizer, deg. fahr	362	345	336	348	318	327	313	294	299
CO_2 in economizer gases, per cent	12.89	12.87	13.25	12.81	13.25	12.75	12.93	13.09	13.11
O_2 in economizer gases, per cent	6.30	6.40	5.95	6.51	5.95	6.51	6.33	6.09	6.12
	Per cent								
Heat absorbed, boiler and economizer	91.32	90.57	91.02	90.44	90.44	90.17	89.65	89.63	89.61
Loss in dry flue gases	3.68	4.39	3.96	4.51	4.50	4.77	5.25	5.27	5.29
Loss due to hydrogen in coal	3.72	3.76	3.74	3.77	3.78	3.78	3.82	3.82	3.82
Loss due to moisture in coal	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
Loss due to radiation, unaccounted for, etc	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

and boiler-test results already described, using Figs. 1 and 8. As these figures are representative of the normal operating cycle, the last column is representative of the B.t.u. per kw-hr. gross for steady-load conditions.

Fig. 11 shows the change in B.t.u. per kw-hr. gross for different constant generator outputs and amounts of steam bled. Fig. 12 shows the B.t.u. per kw-hr. gross for different constant generator outputs plotted against feedwater temperatures.

Figs. 13 and 14 show the degree to which the total station performance is affected by changes in boiler performance due to steam bleeding, as one curve is based on a constant boiler-unit efficiency of 90.5 per cent and a superheat of 250 deg. fahr., and the other on actual conditions which resulted in a decrease in boiler-unit efficiency and a decrease in steam superheat due to steam bleeding.

Conclusions

For installations without economizers the change in boiler performance with a change in feedwater temperature will probably be greater than for installations with economizers, as the economizer has the effect of absorbing part of the change in feedwater temperature as shown in Table 2 in which the rise in water temperature through the economizer is seen to decrease as the temperature of the feedwater increases.

II—Turbine, Condenser, and Generator Characteristics

Fig. 15 shows the change in turbine water rate at constant loads, constant pressure, and constant superheat with variable back pressure. At back pressures of 0.4 in. of mercury there is still a decrease in water rate with a decrease in back pressure for loads up to 25,000 kw., but the limiting vacuum for a load of 30,000 kw. is about 0.7 in. of mercury.

Figs. 16 and 17 show the change in turbine water rate due to a change in the degree of superheat. It is of interest to note that the commonly used figure of 1 per cent correction for 10 deg. change in superheat was also shown in the tests. In drawing these curves the actual data were corrected to constant conditions of back pressure and generator power factor.

The majority of the tests were run with a steam pressure of 235 lb. per sq. in. gage, but one series was run at 250 lb. per sq. in. gage. The tests indicate that the pressure-correction data furnished by the manufacturer of 0.2 per cent for a change of 10 lb. per sq. in. before the load at which the overload valve opens, and 0.4 per cent for a change of 10 lb. per sq. in. above the load at which this valve opens, is correct.

The step in the water-rate curves of Fig. 18 occurs at the point at which the overload valve opens. This point is influenced by both the initial steam pressure and the condenser back pressure. The overload valve opens approximately where the lines marked *A* meet the line marked *B*. The lines marked *A* represent the turbine head pressure or the pressure between the throttling valve and the turbine. The line marked *B* represents the head pressure when the throttling valve is wide open. As shown by the curves a decrease in the condenser back pressure causes the step in the curve to occur at a higher load. An increase in the main steam pressure has the effect of raising the line *B* vertically and causing the step in the curve to occur at a higher load.

Fig. 19 shows the change in condenser back pressure due to a change in the air content of the turbine exhaust steam. Air was bled into the turbine exhaust casing through nozzles which had been calibrated by an orifice. The air removed from the condenser by steam-jet ejectors was measured by an orifice placed in the discharge from the ejector.

Fig. 20 shows the change in condenser back pressure due to a change in the amount of circulating water.

Welding on Boilers

By S. W. MILLER[1]

IN VIEW of the ever-widening applications of fusion welding throughout industry and the probability that repairs to boilers made in this way will be proposed from time to time, it is well that those responsible for the results should bear several points in mind. For simplicity, these are listed briefly below:

1 Most boilers are insured.

2 Many boiler-insurance policies are so worded that if repairs are made without the authority of the company carrying the insurance, the policy becomes void.

3 There are federal, state, and municipal regulations governing this work, as well as those issued by the insurance companies.

4 Only competent welders, used to boiler work, should be allowed to do the welding.

Therefore, the following precautions should be observed by the owner or his representative:

1 Examine the part of the boiler to be welded in company with the insurance-company inspector, and get his approval before doing any welding.

2 Be present at the test after welding with the inspector.

3 If it is possible to do so, get the inspector to sign a statement that the work has been properly done and that it has passed the test successfully.

4 If the boiler is not insured, and comes under federal, state, or municipal supervision, carry out the above program in company with the proper authority.

If the boiler is neither insured nor under supervision of some constituted authority, ample precautions should be taken by the welder and the owner to protect themselves against possible future trouble. They should make a sketch of the location and size of the repair, with a clear statement of what was found wrong and how the repair was made. They should always make a hydrostatic hammer test of the finished job, using a pressure of $1^1/_2$ times the working boiler pressure, in the presence of witnesses, and get their signature to a statement of the facts. These papers should be carefully filed away. In such a case no welding should be done which is not permitted by law or by good practice.

In case of marine work, the welder should pass the regular examination of the Federal Steamboat Inspection Service.

In all cases the welder should make friends of the insurance and other inspectors by refusing to do work unless authorized by them, by being conservative in what work he recommends, and by doing nothing except a first-class job.

[1] Past-President, American Welding Society.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS (See also MILITARY ENGINEERING: Aircraft-Bombing Accuracy)

Effect of Altitude on the Power of Aircraft Engines

THE author considers the question of decrease in power output of aircraft engines due to altitude from a point of view of thermodynamic theory and comes to conclusions which, while not differing materially from those obtained by the use of Welter's law, are applicable not only to gasoline engines but to other internal-combustion engines.

Among possible remedies for this decrease in output he considers the effect of increasing the compression ratio on the height factors, and proposes a mechanism for increasing the compression ratio with height.

The wheel A (Fig. 1) being fixed to the crankcase, drives the wheel C by annular gearing as the crank rotates. The motion of C is transmitted by a train of wheels, all the axles of these wheels being fixed to the crank web, to the last wheel B, which is made in one piece with an eccentric on the crankpin. The large end

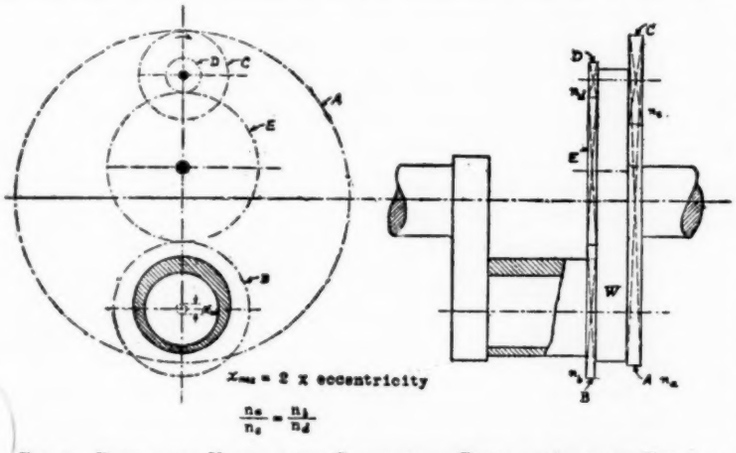


FIG. 1 DEVICE FOR VARYING THE COMPRESSION RATIO OF AIRCRAFT ENGINES

of the connecting rod is clamped to this eccentric. A table included in the original article shows that if A be fixed and the crank web W makes one revolution relatively to A, the wheel B makes

$$\left(1 - \frac{n_a\, n_d}{n_c\, n_b}\right) \text{ revolutions.}$$

If we take $n_a/n_c = n_b/n_d$, then wheel B makes no rotation about its own axle when wheel A is fixed. If we are to modify the compression ratio, then turn the wheel A by any means from outside the crankcase, and the wheel B will also rotate about its own axle more or less according to the amount of rotation of A. Thus the rotation of wheel B varies the crank radius by $x = e\ (1 - \cos\theta)$, approximately, in which e = eccentricity and θ = angle of rotation of B; moreover the above-mentioned table shows that the angle of rotation of B is exactly equal to that of A.

Increasing the compression ratio may, however, bring premature ignition of the fuel mixture. The author gives a table showing the maximum allowable compression ratio at any height. If the controlling level of the wheel A be actuated by a calibration of temperature, the pilot will be able to adjust the compression ratio to the atmospheric temperature, making the engine run with the most favorable value of compression ratio for any height or season. The effect of preheating of fuel gas is discussed in an interesting manner, likewise the effect of richness of fuel gas on the engine power. (Akira Kobayashi, in *Journal of the Society Mechanical Engineers* (Japanese), vol. 28, no. 101, Sept., 1925, pp. 551–601, 18 figs., *t*)

Aircraft in British Army Maneuvers of September, 1925

THE Army maneuvers of September, 1925, had for their main purpose the comparison between an army employing largely mule and horse transport and one relying practically entirely upon mechanical transport. Another purpose of the maneuvers was to determine the value of aircraft.

The following represents an abstract of two reports, one by Major F. A. deV. Robertson, and the other by the editor of *The Aeroplane*, a British aeronautical publication which at times has vigorously criticized the Air Ministry.

Major Robertson was profoundly impressed by the air work during these maneuvers. In the first place, the Army Coöperation Squadrons showed that they could reconnoiter and send in reports in very vile weather. Their patrol work was unceasing. The wire- and radio-communication methods worked well, as was proved by the promptitude with which the single-fighter Grebe planes always answered the call of the big Bristols. A considerable number of machines were put out of action by the umpires as the result of ground fire, but it is possible to doubt whether the losses from ground fire would be actually so great in real war.

The main thing which struck Major Robertson, an observer apparently thoroughly familiar with the subject, was that—

> . . . the army is appallingly short of aircraft on which it can count to work with when the next war breaks out. Sir John Salmond's air-defense force is still too small though it is growing. It would be absolutely impossible for the Commander-in-Chief of Air Defenses to lend the army two squadrons of fighters and two of bombers in wartime. The army would have to do the best it could with its four squadrons, and perhaps one special flight. When only four army divisions took the field that air force had to be temporarily doubled. What would happen if the whole British Army were mobilized, and the borrowing of squadrons suddenly became an impossibility? The Admiralty has done the wise thing by insisting on so many flights and paying for them. The sooner the War Office follows that example, the sounder we shall all be able to sleep in our bed o'nights.

The Editor of *The Aeroplane* does not think much of "ground-straffing" (raking ground forces with machine guns from airplanes). In the first place, as he shows, the chances of damage to the ground forces are slight; and in the second place, as a machine dives and as it zooms up again it offers a good mark for shot from the ground. It is true that it might be hard to hit a vital spot with a rifle, but a good machine gunner ought to be able to do it. Furthermore, special anti-aircraft guns or projectiles might be used for this purpose.

During the war (1914–1918) a very keen game shot raised precisely this subject in relation to ground-straffing airplanes. He pointed out that a rifle bullet, whether fired from a rifle or a machine gun, will make a clean hole through a strut or an engine bearing without doing any serious damage.

He recalled that when he particularly wanted to plug a large hole in something and had not an elephant-gun handy, he had been in the habit of using a buckshot cartridge in a shotgun and nicking the cartridge case round with a knife just where the charge of shot joined the powder charge. The result was that when the gun was fired the top of the cartridge case came away bodily with the shot and held the shot together till it actually hit something. Then the thing would burst like a shell and make a hole into which one could put his fist. It might be worth while to try some experiments with a development of such a weapon on the structure of some of our old airplanes.

As far as scouting is concerned, the author believes that with

long-range lenses and powerful parachute flares, information can be obtained with photographic accuracy from heights between 15,000 and 20,000 ft., where the machine would be fairly safe against shell fire from the ground. At heights between 5000 and 10,000 ft., except when the visibility is bad, airplanes are comparatively easy marks from the improved anti-aircraft artillery of today.

What the author believes, therefore, is that the real air scout of the future is going to be a terrifically fast single-seater or at most, a two-seater. A small high-speed single-seater can dash about near the ground and look for troops on their own level, and achieve results which cannot possibly be got in any other way. A 200-mile-an-hour airplane 20 or 30 ft. off the ground is much less likely to be hit than is a 100-mile airplane at 5000 ft.

For real long-range high-speed scouting, the author considers machines which w ll do 250 m.p.h. for a couple of hours at a stretch and carry a man and a camera. A machine of that kind can go out and get close-up photographs of troop and train movements 150 or 200 miles behind the enemy's front and get back safely with them, thanks to its enormous speed. (Maj. F. A. deV. Robertson in *Flight*, vol. 17, no. 40/875, Oct. 1, 1925, pp. 629, 640, illustrated, and *The Aeroplane*, vol. 29, no. 14, Sept. 30, 1925, pp. 385–390, *gd*)

AIR ENGINEERING

Experiments on Transmission of Air Waves through Pipes

INFORMATION regarding the corrections necessary for reducing the pressure and velocity measurements made in full-scale work with diaphragm gages connected to pitot tubes by long pipes.

The experimental part of the investigation made for this purpose was divided into two parts. The first consisted of measurements of pressure made with the usual type of diaphragm gage at the ends of pipes ranging up to 122 m. in length and to 0.95 cm. in diameter: (1) when a known pressure was suddenly applied at the near end, and (2) when a simple harmonic variation of pressure was impressed at the near end.

The second dealt with experiments in which more precise methods were applied to the measurements of pressure along open and closed pipes when a harmonic displacement was imposed at the near end. Measurements of displacement were obtained by observing the motion of a soap film at the open end.

The experiments were restricted to frequencies below 2.5 per sec.

The results indicate that the usual type of diaphragm gage is unsuitable for the measurement of fluctuating pressures. A reduction in pressure and displacement and an increased lag in phase result (except where resonance occurs) from (1) an increase in the length of the pipe, (2) a decrease in the diameter of the pipe, and (3) an increase in the speed of fluctuation.

Marked divergence between observed and calculated results shows that existing formulas relating to the transmission of sound waves through pipes cannot be successfully employed for correcting air pulsations of low frequency and finite amplitude. (*Aeronautical Research Committee (British) Reports and Memoranda 957* [Ae.176], Jan., 1925, 13 pp., of text, 6 figs., *e*)

AIR MACHINERY (See REFRIGERATING MACHINERY: Flywheel Requirements for Unbalanced Air and Ammonia Compressors)

CORROSION

Anti-Corrosive Paints

THE article here abstracted is largely of a practical character. Where corrosion is present, pigments on a zinc basis should be avoided. It has been found that certain materials, of which zinc oxide and lithopone are two, have the property of aiding rust formation on steel. The author has himself had experience with paints made up on a lithopone basis and ground in a varnish medium known to have extremely good protective powers by itself, which when applied to sheets of black iron and exposed to the weather, within three months had corroded so badly that large pustules of rust could be picked out with a knife, leaving a core in its place. Should a red-oxide paint be used, care should be taken that a natural earth color is employed, as red oxides made by calcination of ferrous sulphate are always liable to contain small quantities of soluble salts or even free acid. When the structure to be painted comes in contact with water rich in chlorides, the use of red lead should be avoided.

Almost any good linseed-oil paint or varnish possesses quite good powers of resistance to acid, in addition to which there are special paints made to meet severe corroding conditions.

One type enjoying quite a wide use is based on bituminous materials. Such paints are good acid resisters and frequently have considerable powers of resistance to alkali as well, but if made so that they dry hard they usually tend to crack badly, and when this stage is reached they are useless. This is sometimes got over by the addition of some non-drying oil, usually mineral in character, but when this is done the film remains very soft, and if it happens to become damaged, its protective powers are completely lost. In any case, all bituminous paints suffer from the disadvantage that ordinary paints cannot be applied over them as the oils in the paint allow the bituminous material to penetrate and, as a consequence, the oil paint becomes discolored and the drying is very much retarded.

There is on the market one very good paint made, it is believed, on a chlorinated-rubber basis. This paint is extremely waterproof and very elastic, but as paints go it is rather dear.

Most of the remaining types depend for their efficiency on a skilfully prepared varnish which is the manufacturer's specialty, and the pigment varies with the color desired; in most cases red or brown earth colors or black are preferred, so that the pigment itself shall be as resistant as possible to acids. It is obvious that pigments which readily form soluble salts with acids are undesirable, as while they do no great harm while the paint film is intact, directly it commences to wear these soluble salts commence to form, and from that time on the deterioration is rapid.

Tests for anti-corrosive paints are described in the original article. The last problem considered is the corrosion of the paint itself. It is frequently desired to paint over freshly prepared cement or plaster surfaces. Owing to the alkaline nature of these materials while they are setting and hardening, an ordinary paint, if applied under twelve months, will flake off in the course of a few weeks. Several of the larger manufacturers now make a preparation which resists this alkaline action and enables painting to be carried out with perfect safety after about a fortnight has elapsed.

It is not generally realized that ordinary town gas produces approximately one grain of sulphuric acid for every cubic foot of gas burnt. This does not seem a great deal, but the author recalls very vividly a wall which had been beautifully finished with a flat paint, immediately over a large gas cooker. After a few months the whole surface was developing star-shaped cracks, and was covered with small needle-shaped crystals. Examination of the wall showed that similar crystals formed the nucleus of each of the cracks, and analysis proved that the crystals were zinc sulphate, derived from the zinc pigment employed and the sulphuric acid from the gas. A cure was effected by the use of a paint with better acid-resting properties. (R. G. Daniels in *The Industrial Chemist and Chemical Manufacturer*, vol. 6, no. 1, July, 1925, pp. 271–272, *p*)

ENGINEERING MATERIALS

Furnace Ash as a Refractory Material

IN BOILER-FURNACE refractories the most important materials as far as quantity goes are shapes, i.e., brick and tile. Next in order are the cements and patching materials.

A survey of the power plants throughout the United States discloses that the maximum furnace temperature as properly recorded by the pyrometer is less than 3000 deg. fahr. As far as heat alone is concerned, any of the usual refractories will withstand it without mechanical load, and high-grade firebrick will withstand a load of 10 to 15 lb. per sq. in. under this temperature. High-grade flint brick dry-pressed with little if any plastic clay will take loads up to 25 lb. per sq. in. at this temperature without failure by squatting.

The reason for the failure to stand up under present-day opera-

tion is due chiefly to a reduction in melting point by fluxing with the fuel constituents. One way suggested to increase the resistance to fluxing and at the same time to maintain a good mechanical structure is to construct the shapes of a coarse-textured material formed under high pressure (2500 lb. per sq. in.) with as little plastic material as possible, and then coat the furnace interior with a refractory wash. The function of the wash is to act as a neutral body to the combination with either the firebrick or the slag. Of importance also is patching the spots where bricks fail, and with this in view a study was made of coal ash.

The typical analysis of ash from different coals does not show any more difference than the analysis of clays used in the manufacture of firebrick. The usual range is as follows: Silica, 40 to 60 per cent; alumina, 20 to 35; ferric oxide, 5 to 25; calcium, 1 to 15; magnesium, 0.5 to 4; sodium and potassium, 1 to 4; sulphur 0.1 to 4 per cent.

A further investigation has shown that refractories made of simple silicate are easily combined with slags, while more complex silicates, though having a lower melting point, are far more stable and less liable to form combinations with slag. It is for this reason that ash often lends itself to employment as a refractory material.

To use ash as a patching material, certain requirements have to be satisfied. To begin with, ash should have a primary fusion point of 2500 deg. fahr. or better, and proper attention should be paid to the iron and sulphur content. Sodium and potassium compounds are detrimental. Large masses of clinker should be removed from the ash. The ash must then be properly treated by crushing and impregnating with water to remove the alkalies. This may take from three months to a year. The ash is then dried and mixed with five per cent of bentonite. This addition of bentonite turns the non-plastic into a plastic mixture that can be worked easily. The material as made can be used in the form of bricks or for patching holes.

A complete schedule of tests was made of various mixtures. There were tests also of mixtures of ash in which special treatment had been given to increase the melting point by the addition of titanium, aluminum, and other oxides. These tests show that brick can be made that have as good characteristics as regular grades of firebrick. Tests of the mortars as bonding agents show that a good bond can be made as strong in many cases as the brick, and in other cases stronger than the brick itself. In such bonding tests regular firebrick was used, bonded under a load of 2 lb. per sq. in. and at various temperatures. The strength of the bond was tested in shear. Three bricks being bonded together, the outside brick was placed on a stand over an aperture through which the inside brick was forced upon failure by slipping on the bond or fracture of the bricks.

Ash treated as described here and initially of a melting point of 2500 deg. fahr. had a melting point after treatment around 3000 deg. fahr. The mixture worked well as a patching material and as a bond, and one course was set with alternate pieces of high-grade firebrick of a well-known make and brick made of the ash mentioned in this paragraph. The ash brick were handmade and probably would have stood up better if made by machine with a heavy pressure.

It is not the purpose of this paper to recommend the use of ash as a brick-making material, although it has possibilities. (Hugh E. Weightman, Consulting Fuel Engr., St. Louis, Mo., in *Power*, vol. 62, no. 15, Oct. 13, 1925, pp. 557–560, 3 figs., *gp*)

FOUNDRY

A Method of Improving the Properties of Aluminum-Alloy Castings

THE experiments here described form part of the research on light aluminum alloys in progress at the Laboratory for the Engineering Co-ordinating Research Board, and have been carried out with the object of improving the soundness and mechanical properties of these alloys in the cast condition.

Up to the present Y-alloy (copper, 4 per cent; nickel, 2 per cent; magnesium, 1.5 per cent; aluminum, remainder) has been the principal alloy studied. The experiments and the results obtained from them indicate the possibilities of a method of treating aluminum and certain of its alloys which serve to eliminate at all events a considerable proportion of dissolved gas and thus reduces unsoundness, and to a considerable extent removes pinholing. The process consists in allowing the molten alloy or metal to cool slowly in the crucible in the furnace until it has just completely solidified; it is then remelted and may be carefully stirred, raised to the pouring temperature, and cast. Ordinary ingoting of the metal is not satisfactory, as the ingots cool too quickly and during remelting are too much exposed to the furnace gases.

In a later experiment, passage of nitrogen through the melt during slow cooling and solidification has been found to improve still further the soundness of resulting sand-cast bars.

Slightly anomalous results have been obtained in some cases, and it is not yet clear how far the method is of value in other alloys. Further investigation is required. Meanwhile the author has learned, and is authorized to refer to the fact here, that simultaneously and independently Prof. C. A. Edwards and Mr. Prytherch of Swansea, working on the effect of gases in copper (for the British Non-Ferrous Metals Research Association) have discovered a similar effect obtained by solidification in the crucible, in the case of pure copper.

The value of the treatment described for other cast aluminum alloys will be studied and attempts will be made to determine the actual gas contents of castings produced from ordinarily treated melts, and from others to which the special treatment described has been applied. (S. L. Archbutt, F. I. C., of the National Physical Laboratory, in *Reports and Memoranda, Aeronautical Research Committee (British)*, no. 959 (M. 28), Dec., 1924, pp. 1–10, and 2 pp. of illustr. and a table, *ep*)

FUELS AND FIRING

The Bergius Process of Coal Liquefaction

SEVERAL statements made in the German and British press and partly reproduced in MECHANICAL ENGINEERING, vol. 47, no. 10, Oct., 1925, p. 851, gave the impression that the Bergius of coal liquefaction was approaching the state of commercial success. An investigation of the situation by a representative of the *Chemical Age*, a British weekly, would indicate, however, that such is not the case.

It was found that at present the strictest secrecy prevails in the German plants as to the actual stage at which the processes have arrived. No German patents of recent date were found to have been issued, and much caution is being exercised in consequence.

The process patented by Dr. Bergius for the liquefaction of coal is not the only one in the field. The Bergius process is still regarded as in the experimental stage and its commercial success remains to be demonstrated. Dr. Bergius' own experiments at Rheinau apparently have not passed beyond the small scale, and nothing has become known of other more successful investigations on coal liquefaction.

The report of a German state grant or guarantee of 2,500,000 marks toward the cost of erecting works for the treatment of large quantities of coal by the Bergius process has been denied in Germany.

Another German independent chemist, Dr. Fischer, is continuing his work on his "synthol" fuel, a mixture of higher alcohols and ketones.

Obtained by the catalytic reduction of carbon monoxide under high pressure, this fuel is likely to become of commercial importance as has been evidenced by some experiments carried out on it, which are described in detail in Dr. Fischer's latest book, The Conversion of Coal into Oils (Ernest Benn, Ltd.), translated by Dr. R. Lessing. Some road trials were made in order to test the suitability of synthol as a motor fuel, and for this purpose the crude oil, separated from its aqueous liguor, was freed of acid and distilled in a fractionating flask up to 200 deg., when 87 per cent of distillate was obtained. This shows, therefore, that the bulk of this oil is available as a light motor spirit, and in addition its flash point is very low. The running tests were made on a level road and, to restrict the amount of fuel required,

a 4-hp. motorcycle was used with a load of two persons, the speed being kept constant at about 20 m.p.h. The results of these tests showed that although synthol has a lower calorific value than benzol it gives more power, while a mixture with benzol was still more efficient. The engine started readily with synthol alone and ran very smoothly, as also it did with the benzol mixture. The trials, it is stated, were made merely to give an indication whether synthol is suitable as a motor fuel, but the mileage obtained showed that it is equal to benzol and perhaps even superior.

[From other sources it is known that synthol is a mixture of various alcohols ranging from ethyl and methyl to the alcohols containing up to nine carbons. The mixture is produced from water gas and steam catalytically at certain high temperatures and pressures.]

The Badische Co. has recently patented a process for the employment of iron carbonyl as a substitute for lead tetraethyl for addition to motor fuels to produce an anti-knock effect. The new material produces no poisonous gases.

Further large-scale investigations with gasoline mixtures are, however, still necessary to determine the properties of the new material before the fuel can be marketed. (*The Chemical Age*, vol. 13, no. 326, Sept. 12, 1925, pp. 268–269, 2 figs., *g*) (Compare paper by A. C. Fieldner and Ralph L. Brown of the Pittsburgh Station of the Bureau of Mines, presented at the Intersectional Meeting of the American Chemical Society in New York, Sept. 30, 1925, and abstracted in *Chemical and Metallurgical Engineering*, vol. 32, no. 16, Oct., 1925, p. 799.)

Observations on Fuel Research in Europe

THE author, who is connected with the Pittsburgh Experiment Station at the U. S. Bureau of Mines, Pittsburgh, Pa., went to Europe in June, 1924, to observe the methods of fuel investigation, particularly in England.

The British Government appropriated a considerable sum of money before the end of the war to establish a National Fuel Research Station at East Greenwich, London, which is today the largest government-supported experimental station exclusively devoted to fuel research in the world. The production of smokeless domestic fuel and substitutes for petroleum products from low-temperature tar is the major problem now occupying the attention of the staff.

Fundamental research on the constitution of coal is conducted in the Department of Fuel Technology of Sheffield University under the direction of R. V. Wheeler. Wheeler and his associates are attacking the problem of the constitution of coal along broad lines, involving (1) microscopic examination and identification of plant entities; (2) separation of the coal substance into groups by solvent extraction; and (3) treatment of coal and constituent parts of the coal by methods of destructive distillation, oxidation with reagents, and other chemical reactions. The coal constituents are correlated as far as possible with plant constituents by subjecting these to similar treatment and comparing the results. The microscopic and botanical research is conducted at the Imperial College of Science in London.

Recently Clarence A. Seyler, of Swansea, has undertaken the study of the constitution of anthracite. He has developed the wonderful technic in etching polished surfaces of anthracite with chromic acid in such a way as to bring out very clearly the plant structure when examined under the microscope by reflected light. He has shown identical cell structure in anthracite to that shown by Thiessen of the U. S. Bureau of Mines in thin sections of bituminous coals and lignite when examined by transmitted light.

The tremendous volume of research by Wheeler and his associates on the ignition and propagation of flame in gas and coal-dust suspensions impresses one with deep respect for the good judgment of the British Government in supporting true scientific work on the promotion of safety in the coal-mining industry. Further, the fundamental nature of the work makes it of great value to the fuel industry as well. The data obtained on the mechanism of coal-dust explosions are of equal importance in pulverized-coal combustion, as likewise is the work on ignition and propagation of gaseous flames to combustion of gases in industrial furnaces. In the laboratory where this work is done one sees apparatus of very ingenious design for recording flame velocities, measuring pressures and temperatures, and actually taking motion pictures of ignition and propagation of flame through mixtures of gases in tubes and containers of various shapes.

In the Mining Research Laboratory at the University of Birmingham, work is carried on among other things on the absorption of the gases, methane, carbon dioxide, and nitrogen by coal, and on the hydrogenation and liquefaction of coal. Researches on the spontaneous combustion of coal have been more extensive at this station during the last fifteen years than anywhere else in the world.

A laboratory for the investigation of fuel- and coal-mining problems is supported at the College of Technology at Manchester by the Lancashire and Cheshire Coal Owners' Association. The Institution of Gas Engineers of Great Britain maintains at the University of Leeds certain fellowships in gas-engineering research. Work is done on such problems as the influence of steaming and method of carbonization and gasification on the lubrication of nitrogen and of sulphur, efficiency of gas appliances, heat of reaction in the carbonization of coal, etc. Some data are presented on low-temperature carbonization where in particular the Parker retort process and the Maclaurin process were used.

In Germany one is at once impressed by the close coöperation of the government, the universities, and the industries. Although the present government does not directly support fuel research, it does actively promote and coördinate the work of a number of research institutes and association laboratories supported by the industries through a Fuel Research and Utilization Committee of the Reichskohlenrat. The two Kaiser Wilhelm Institutes for Coal Research—the one at Mülheim-Ruhr and other at Breslau—and the Institute for Brown Coal Research at Freiberg are supported by industrial groups in the particular district in which they are located. The directing staffs are in close touch with both the universities and the industries. A large working portion of the working staffs of these institutes consists of students from the universities taking their post-graduate research work for the Ph.D. degree.

Before the war these institutes, as well as the university laboratories, were engaged almost exclusively on fundamental scientific research. But since that time, owing to the loss of their supporting endowments, they have been obliged to turn their principal efforts to meeting the immediate problems of the industry in the substitution of brown coal and inferior grades of bituminous coal for the high-grade Ruhr coals which had to be exported on reparations account.

The leading coal-research institute in Germany is the one directed by Franz Fischer at Mülheim-Ruhr, in the heart of the Westphalian coal fields. The problems come under three main headings: (1) The constitution and origin of coal, (2) the coking constituents of coal, and (3) the production of oil from coal. The outbreak of the war within a few months after the completion of the institute naturally diverted the main energy of the first five years of its existence to the problem of making petroleum substitutes from coal. The small laboratory rotary retort was the forerunner of the large Thyssen and Fellner-Ziegler low-temperature retorts, which were put into commercial operation during the period of petroleum shortage. Research on the composition and utilization of low-temperature tar from various bituminous and brown coals is one of the important current problems.

The most interesting problems, however, were those involving reactions at high pressures. Fisher has developed technic and special apparatus of great variety for extracting coal with solvents at temperatures considerably above the boiling point of the solvent for oxidizing coal and coal constituents in the presence of various reagents under pressure, for studying the action of carbon monoxide and of hydrogen at high pressures, and for the production of combustible liquids from the interaction of carbon monoxide and hydrogen in the presence of catalysis at high pressures and temperatures. By these methods of attack he has obtained data supporting the lignin theory of the origin of coal, and has produced "synthol," a gasoline fuel substitute, from carbon monoxide and hydrogen. A problem of practical interest was the insolation of the coking and swelling constituents of coal by extraction of the coal with benzene at 250 deg. cent. and treatment of

the extract with petroleum ether. (A. C. Fieldner, Pittsburgh Experiment Station, U. S. Bureau of Mines, Pittsburgh, Pa., in *Industrial and Engineering Chemistry*, vol. 17, no. 10, Oct., 1925, pp. 1046–1050, illustrated, *gce*)

HYDRAULIC ENGINEERING

Pelton-Wheel Design

SOME practical notes on the design of Pelton wheels by means of specific-speed relations. The author expresses the wheel ratio, number of buckets, and the ridge inclination as functions of the specific speed, and draws a standard jet diagram to determine the chief dimensions of the wheel. Among other things, the peripheral coefficient of the Pelton wheel is considered. (Kenichi Minamioji (in Japanese) in the *Journal of the Society of Mechanical Engineers* (Japanese), vol. 28, no. 100, Aug., 1925, Tokyo, pp. 471–488, 11 figs., *p*)

INTERNAL-COMBUSTION ENGINEERING (See also AERONAUTICS: Effect of Altitude on the Power of Aircraft Engines)

The Atlas Diesel Marine Engine

THIS engine (two 1250-b.hp. four cycle single-acting units have been constructed for installation in a Swedish cargo ship) utilizes a peculiar system of starting. Normally starting air is admitted through valves located in the cylinder cover. In this engine the air is admitted to the cylinders below the pistons through valves actuated from cams on the camshaft. Lower air pressure may be employed, as it is possible to give an impulse to the piston every other stroke instead of every two revolutions as with the normal four-stroke single-acting engine. The system has also the advantage that no cold starting air is introduced into the combustion chamber while maneuvering, and the absence of the starting valve in the cylinder cover gives more freedom in improving the design. (*The Times Trade and Engineering Supplement*, vol. 17, no. 378, Oct. 3, 1925, p. 66, *d*)

Michell Crankless Engine under Test

THIS engine, designed by A. G. M. Michell, was described in MECHANICAL ENGINEERING, vol. 43, no. 5, May, 1921, p. 338. Its essential features is the use of the Michell bearing in the swash plate.

The engine under test was of the eight-cylinder horizontal type designed for direct driving of a crankless type of gas booster and was rated at 100 b.hp. when running on town gas at 750 r.p.m. The cylinders were $5^1/_2$ in. bore and $6^1/_2$ in. stroke, with compression ratio of 5.7 to 1. The tests were conducted at Melbourne by A. J. Gibson, lately professor of engineering in the University of Queensland, now a consulting engineer.

In the tests the engine was run at speeds from 350 to 850 r.p.m. with various brake loads. It was found that over a range of speed at a practical brake load the indicated horsepower was practically constant and that the engine developed from 112.5 to 31.2 hp. at speeds corresponding to 750 r.p.m. and various brake loads.

The average efficiency of five tests under a brake load of 180 lb. and revolutions from 600 to 750 r.p.m. was 90.5 per cent. At lower brake loads (150 lb.) the efficiencies were respectively 81.2 and 74 per cent with brake horsepowers of 62.5 and 31.2, which is rather low. At full rated load a mechanical efficiency of 89.5 per cent and a thermal efficiency of about 28 per cent may reasonably be expected. The engine operated without vibration and apparently with ample lubrication. (*Gas and Oil Power*, vol. 21, no. 241, Oct. 1, 1925, pp. 1–2, 1 fig., *e*) (For a further description of the new design of the Michell engine, see the *Automobile Engineer*, vol. 15, no. 207, Oct. 5, 1925, pp. 316–320, 13 figs. According to this article the most notable feature of the Michell engine is that it is in perfect dynamic balance in all respects and at all speeds, and that the plan is determined in the design and is effected by ordinary accuracy in the machine-shop operation, no adjustment of the balance by trial being necessary.)

The Limit of Piston Speed in a Double-Acting Two-Cycle Oi Engine as Affected by Bearing Pressure

THE author has plotted combined pressure and inertia curves for the M.A.N. submarine engine and computed and plotted the resultant load factor for the crankpin bearing (the load factor is the product of the mean bearing pressure and the rubbing velocity expressed in foot-pounds per second); also bearing pressure and load factor curves have been computed for a double-acting two-cycle engine with a weight of reciprocating parts equal to 30 lb. per sq. in. piston area and for a double-acting two-cycle engine with a weight of reciprocating parts equal to 20 lb. per sq. in. of piston area.

The following facts are noted:

1 For the double-acting engine with a value of weight of reciprocating parts equal to 20 lb., the curve of total bearing pressure shows a marked decrease until a piston speed of 1600 ft. per min. is reached.

2 For the double-acting engine with a value of weight of reciprocating parts equal to 30 lb., the curve of total bearing pressure shows a materially smaller pressure than the above, until a piston speed of about 1400 ft. per min. is reached.

3 For the double-acting engine with a value of weight of reciprocating parts equal to 20 lb., the value of the load factor at 1600 ft. per min. is 6231 ft-lb. per sec.; which is but 74 per cent of that of the M.A.N. engine at normal full load.

The superiority of the two-cycle, double-acting engine over all other types is apparent.

It is probable that other factors, the most important of which is the necessity of maintaining a good propeller efficiency, will limit the piston speed to about 1300 ft. per min. At this speed the load factor is about 5000 ft-lb. per sec., which is 60 per cent of that of the M.A.N. engine, and where the two load-factor curves cross, the advantage to be derived will be in the shorter bearings required, resulting in a materially stiffer shaft and in a material decrease in the bending moments on the cylinder housing due to the reduced distance between cylinder centers. (A. M. Procter, Capt. U. S. Navy, in *Journal of the American Society of Naval Engineers*, vol. 38, no. 3, Aug., 1925, pp. 547–550, and a sheet of charts, *tA*)

The Beardmore All-Steel Quick-Running Diesel Engine

DESCRIPTION of a new four-cycle high-compression airless-injection type developed in the last year by William Beardmore & Co., Ltd., Parkhead Works, Glasgow.

The new design was developed with a view to providing a high-powered small and light engine which would be particularly suitable for the propulsion of rail cars, Diesel-electric locomotives, and high-speed marine craft.

With this object in view steel construction has been adopted throughout. In the smaller sizes of engines the weight per brake horsepower varies from 16 to 12 lb. while in the larger units it has been reduced to almost 10 lb. At present the engine is constructed in two different series with cylinders of $8^1/_4$ and 12 in. bore and a stroke of 12 in. The normal speed in both cases is 750 r.p.m. The series of smaller units comprises a range of five engines with from 2 to 12 cylinders designed for outputs of from 100 to 600 b.hp. In the series of larger units there is a range of four engines, from 420 to 1260 b.hp. In addition to this a special design has a V-form with powers up to 2000 b.hp.

In many features of design the engine is similar to the gasoline engine built by the same concern. One of the noticeable features is a steel monobloc crankcase, the upper part of which is bored out to receive the steel liners and so forms the common water jacket around the liners. The main crankcase casting carries the crankshaft bearings and also strong base supports for bolting the engine to its foundations which are cast integral with it. The connecting rods are made from special steel forgings and are carefully finished all over and tested for weight. The top end bearing of the rod has a solid phosphor-bronze bush, while its large end is fitted with a pair of white-metal-lined phosphor-bronze bushes, fitted with an adjustable liner, and both the bearings of the connecting rod arranged for pressure lubrication. The pistons are of special interest. They are made from forgings of a special aluminum alloy and they are machined all over and balanced before finishing.

Each piston carries six cast-iron piston rings in addition to a scraper ring fitted below the gudgeon pin. The latter pin is of the full-floating type and is made of ground case-hardened nickel steel.

Very light machined-steel liners are pressed into the main crank casing; several liners which had been dismantled after test showed a very smooth and highly polished internal surface. The cylinder heads are made of an aluminum alloy and provided with large water-cooled spaces. Each cylinder head carries two exhaust valves, two inlet valves, and a central automatic fuel-spray valve as well as a compression release valve. Separate fuel pumps for each cylinder are employed and a primary pump maintains a low pressure on the suction side of the main fuel pumps. The injection is timed and the engine output is controlled by varying the effective piston delivery stroke. When it is considered that the engine runs at a speed of 750 r.p.m. and that the fuel injection takes place over not more than 30 per cent of the working stroke, it will be appreciated that very fine workmanship is required with this pump.

Some of these engines have been installed on Diesel-electric cars of the Canadian National Railways. The original article reports results of tests carried out by Prof. A. L. Mellanby, Royal Technical College, Glasgow. From this it would appear that the fuel consumption per brake horsepower hour (centrifuged Shell-Mex Diesel oil) is 0.418 lb. and the lubricating oil consumption per brake horsepower hour is 0.01. (*The Engineer*, vol. 140, no. 3640, Oct. 2, 1925, pp. 344-345, 4 figs., *d*)

MACHINE PARTS AND MACHINE DESIGN

New Enveloping-Type Internal Gear

THE principle of the tooth action of this gear is very simple and may be explained by reference to Fig. 2. AB and CD are the pitch circles of the pinion and internal gear, and if, using these pitch circles as base circles, a pair of involutes OP and OQ be generated, these will represent the tooth profiles of the pinion and wheel, respectively. The condition to be fulfilled by a pair of odontically conjugate teeth is that the common normal at the point of contact shall always pass through the pitch point. In Fig. 2, if the gears be turned at their correct angular velocities until the profiles reach any positions MQ_1, NP_1, the profiles will be in contact at the point R, which is the point of intersection of the profiles with the tangent OR from the pitch point. This may be proved in the following manner: Since the profiles were in contact at the point O, and since the pitch line velocities must be equal, the distance ON must be equal to OM. Also the length OR must equal the arcs OM and ON, since MR and NR are involutes. From this it follows that the profiles must be in contact at R. It is also obvious that OR is normal to both profiles, and therefore the necessary conditions are fulfilled.

It will be seen that all points of contact must lie on OR, i.e., OR is the line of action, and this line being horizontal, the angle of obliquity is zero.

As shown in another drawing in the original article, the fit which is attained between the mating teeth of the new gear is very close and becomes better the further the point of contact is from the pitch point; which is as it should be, since the velocity of sliding between the teeth becomes greater as the point of contact moves away from the pitch point, and good fit means better provision against wear.

The reason why such a close fit is obtained between the teeth of the new gear is that the instantaneous radii of curvature of the pinion and wheel profiles at the point of contact are always equal to each other. (Referring back to Fig. 2, it is obvious that OR is the instantaneous radius of curvature of both the profiles MQ_1 and NP_1, since the line OR is rolling about the two base circles to produce the involute profiles.) The standard measurement of the closeness of fit between two curved surfaces is equal to $\frac{1}{2}\left(\frac{1}{A}+\frac{1}{B}\right)$, where A and B are the instantaneous radii of curvature of the two curves, each being taken as positive if convex and negative if concave.

It is obvious that in the case of the new gear this value is equal to zero for any point of contact whatever, i.e., closeness of fit is the maximum possible at all points. In the case of the standard gear, however, the instantaneous radii of the profiles at the point of contact are never equal. Considering for instance, the point of contact D, the radius of curvature of the pinion profile at this point must be equal to AD and that of the wheel must be BD; scaling these off and adding the necessary signs, the value of the closeness of fit becomes equal to 0.1.

The tooth strength of the pinion of the new gear is claimed to be greater than in standard gears, and is said to be due to the fact that its base circle lies at the root of the teeth and does not, as in standard gears, meet the profiles part way up the flanks of the teeth. The tooth action of the new gear takes place entirely in the arc of the recess, thus eliminating the friction of approach which is usually considered to be slightly greater than that of recess. There is also a difference in the way interference occurs between the tips of the teeth of the gears and the point where the pinion tooth enters the addendum circle of the internal, the advantage being in favor of the new gear.

The number of teeth in the pinions in the new gear can be made as low as three without impairing the correctness of the

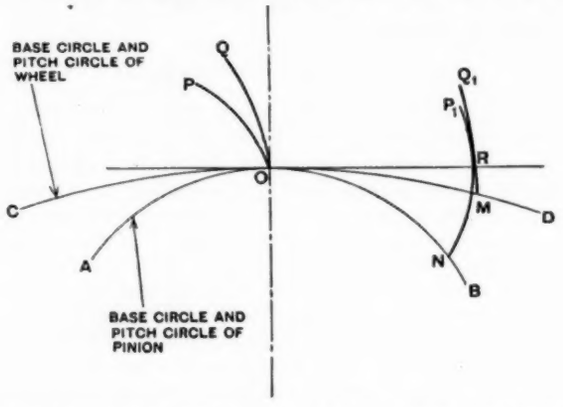


FIG. 2 DIAGRAM ILLUSTRATING THE THEORY OF THE NEW GEAR

gears. The original article shows a pinion of four teeth gearing with a wheel of sixty teeth, and another illustration, a four-tooth pinion gearing with an eight-tooth wheel. It is also claimed that the sliding velocity of the new gear is very much greater than that of the standard gear, the ratio being about 2.5 to 1. Also the ratio of sliding contact to rolling contact in the new gear is very much greater than the corresponding ratio for the standard gear. While the new gear had disadvantages in these respects, it is said that it also has less load to withstand at the point of contact owing to the greater number of teeth in contact. Also the nature of the contact may be considered almost as surface contact, owing to the closeness of feed which is attained, and it is said that these two factors will more than counteract the effect of wear of the teeth caused by the high sliding velocity.

While the new gears work correctly at extended center distances, they will not work at closed centers with theoretical accuracy. It is shown in the article, however, how to handle this problem.

As the profiles of the teeth are involutes the gears can be generated on the ordinary gear-cutting machines with cutters which will probably require to be only slightly different from standard, and the method of doing it is described in the original article. It is not stated who manufactures these gears. (H. Walker, in *Machinery* (London), vol. 26, no. 678, Sept. 24, 1925, pp. 822–826, 11 figs., *d*)

Hele-Shaw Beacham Variable Transmission Gear

THE Hele-Shaw continuously variable transmission gear involving the so-called floating ring is well known. It had limitations, however, in that first the floating ring could not be made larger than certain dimensions, and in the second place the gear was not quite noiseless, its work being accompanied by a characteristic hum, which was held to make impracticable its use on submarines. T. E. Beacham traced this hum to the deformation of the ring and its subsequent recovery of form as the load progresses from

point to point of the circumference. This led to a redesign of the gear.

Like the former Hele-Shaw gear, the new gear consists of two main components, namely, a pump with a variable stroke and a constant-stroke hydraulic motor. As now made it is proposed to fit the gear to a 500-hp. Diesel-electric locomotive. The arrangement adopted provides that at low torques the gear is out of action and the wheels are direct-driven. As the resistance rises, more and more of the power is transmitted hydraulically, and at maximum torque the amount will be one-third of the total. Under these conditions the gear will waste in friction only about 5 per cent of the total power supplied to the wheels.

From curves given in the original article the maximum efficiency of the pump at full stroke is about 94 per cent and at half-stroke, about 88 per cent. Tests of the complete gear are also briefly reported in the original article where the design is explained in detail. (*Engineering*, vol. 120, no. 3120, Oct. 16, 1925, pp. 477–480, 19 figs., *d*)

MARINE ENGINEERING

U. S. S. "Dobbin" and U. S. S. "Whitney"

DESCRIPTION of hull and machinery installations of two ships intended to act as repair shops, and, to a certain extent, as hospitals for the fleet. The U. S. S. *Dobbin* was described in MECHANICAL ENGINEERING, vol. 46, no. 4, April, 1924, pp. 173–178. The present article, however, gives further details on this interesting installation. (Lewis Hobart Kenney, Mem. A.S.M.E., in *Journal of the American Society of Naval Engineers*, vol. 37, no. 3, Aug., 1925, pp. 435–531, 5 figs., *d*)

"Watermota" Outboard Marine Engine

DESCRIPTION of an engine made in England by Walter D. Fair & Co., Pembroke Engineering Works, Hampton Wick, Kingston-on-Thames. It was developed early in the war in collaboration with the Admiralty engineers. Among the features claimed as being unusual are the following. The anti-friction metal bearings of the engine and of the propeller mechanism are renewable. This is important, especially in the case of the two-stroke engine, as it is necessary for efficient working that the crankshaft bearing should be a good fit. The weight of the crankshaft and the flywheel are taken by a ball thrust bearing in the crankcase, insuring perfect alignment between the crankpin, connecting rod, and piston.

The water jacket is a copper envelope (not cast integral with the cylinder) which cannot be cracked by frost. Moreover the jacket can be removed if necessary to empty out any muddy deposit from the circulating water. At normal speed of 900 r.p.m. the engine is said to develop from 3 to 4 hp. and to run for four hours on a (British) gallon of fuel. (*The Machinery Market*, no. 1300, Oct. 2, 1925, p. 28, 3 figs., *d*)

High-Pressure Boilers on the "Malolo"

THE boilers of the new Matson Line steamship *Malolo* now being built at the yards of William Cramp & Sons Co., Philadelphia, Pa., will be of higher pressure than any previously used on any American passenger steamship. The working pressure will be 280 lb. per sq. in. and will be generated in 12 water-tube boilers of the Babcock & Wilcox marine type. The superheat will be 100 deg. fahr., and possibly higher. The boilers will be equipped for burning oil under forced draft. All pressure parts will be constructed entirely of open-hearth steel plate and seamless steel tubes. No malleable or cast iron or cast steel will be used under pressure. The steam and water drums, 42 in. in diameter, will be made of open-hearth steel plate. The longitudinal seams will be butted and strapped inside and out. The drum heads will be spherically bumped and flanged by hydraulic pressure, and the boiler will be encased by a practically airtight casing consisting of suitable steel plates arranged in removable sections braced by angle irons and bolted to the foundation. In all boilers zinc protectors and baskets will be fitted. (Charles Johnson Post in *Marine Engineering and Shipping Age*, vol. 30, no. 10, Oct., 1925, pp. 582–584, 3 figs., *d*)

High-Pressure Steam Plant for a Steamship

IN THE June, 1925, issue of MECHANICAL ENGINEERING (vol. 47, no. 6, p. 507) reference was made to a high-pressure steam plant for a steamship. This is now being built at the works of William Denny & Bros., Dumbarton, and it is announced that the twin-screw turbines will be of 4000 hp. and will operate through mechanical reduction gearing. They will be supplied with steam by two water-tube boilers working at a pressure of from 500 to 550 lb. per sq. in. and at a temperature of from 700 to 750 deg. fahr. The steam pressure will thus be double that of any existing marine installation. The water-tube boilers will be fitted with air preheaters, the steam for the auxiliary machinery will be used at a reduced pressure, the auxiliary exhaust steam will be utilized for heating the feedwater to about 200 deg. fahr., and the temperature of the feedwater will be increased to about 300 deg. fahr. by steam tapped off from the turbines. (*The Times Trade and Engineering Supplement*, vol. 16, no. 375, Sept. 12, 1925, p. 639, *d*)

MILITARY ENGINEERING

Aircraft-Bombing Accuracy

THE author claims that the present performance of aircraft bombing has an average accuracy of 23 per cent. This opinion is, however, based not on the actual statistical results of bombing tests, but on theoretical considerations. It is stated, though, that the probable error of bombing has been determined from various tests (no information given as to their number and conditions), and is found to vary with the degree of training of the bombing team, the type of equipment used, and the weather conditions under which the bombing was conducted.

E. J. Loring, Mem. A.S.M.E., an authority of bomb ballistics, discussed the subject at considerable length, and after analyzing a large mass of data has proposed the following empirical formula for the probable error of bombing:

$$\text{Probable error (in feet)} = \frac{3\sqrt{\text{Altitude (in feet)}}}{K}$$

in which K is a factor depending upon the degree of training of the bombing team, or a "figure of merit" of the team.

According to Loring, the factor K varies from the "remarkable" 2.0 to "average" 1.0 to 1.25, with an "ultimate" value of 2.5.

He further states that the percentages of hits that may be expected on a battleship target from an altitude of 9000 ft. are from 11 to 28 per cent "direct" hits and from 23 to 53 per cent "direct hits and hits in danger zone."

The original article is illustrated with several photographs showing the wreckage caused by aircraft bombing hits. (Maj. B. W. Simpson, Ordnance Department, U. S. A., in *Aviation*, vol. 19, no. 13, Sept. 28, 1925, pp. 393–396, illustrated, *gt*)

PHYSICS

The Viscosity of Liquids under Pressure

DATA of tests in which the relative viscosity of 43 liquids has been tested at pressures varying from atmospheric to 12,000 kg. per sq. cm. and at temperatures ranging from 30 to 75 deg. cent.

From these tests it was found that the viscosity of all the liquids tested, with the exception of water, increases uniformly with rise in pressure. At low pressures the viscosity increases linearly with pressure, but beyond a pressure of the order of a thousand kilograms the rate of increase rapidly rises, so that a logarithmic curve is necessary to represent the entire course of the curve. It would appear that the effect of pressure on viscosity is greater than on any other physical property hitherto measured, and varies more with the nature of the substances. In general, the results show a correlation between the increase of viscosity under pressure and the complication of the molecule, and the author believes that there may be an important element affecting the viscosity of liquids, namely, an actual interlocking effect between the molecules.

Water is unique in that at low temperatures and pressures

its viscosity decreases with rising pressure instead of increasing. At low temperatures the viscosity passes through a pressure maximum and then increases. With increasing temperature the minimum flattens out, eventually disappears, and at temperatures above approximately 25 per cent the viscosity increases with rising pressure from the beginning. This anomalous behavior of water has been already suspected from previous measurements of viscosity at low pressures. The anomaly is doubtless connected, as are many of the other anomalies of water, with a high degree of association, which changes rapidly with pressure and temperature. (Prof. P. W. Bridgman, Jefferson Physical Laboratory, Harvard University, in *Proceedings of the National Academy of Science of the United S ates of America*, vol. 11, no. 10, Oct., 1925, pp. 603–606, *eA*

POWER-PLANT ENGINEERING (See also ENGINEERING MATERIALS: Furnace Ash as a Refractory Material)

Feedwater System at the New Plant of the Sioux City Gas and Electric Company

IN THIS station the condensers are equipped with hotwells which are approximately 3 ft. deep and extend the full width and length of the condensers. The condensate pumps take their suction from these hotwells and pump through the bleeder heaters and inter- and after-coolers, directly to the suction of the boiler-feed pumps. The boiler-feed pumps deliver the water through the high-heat-level condenser of the evaporator system to the boilers. The boiler-feed pumps are driven by constant-speed a.c. motors, but the drives for the condensate pumps are variable-speed a.c. motors. The quantity of water discharged from the boiler-feed pumps is controlled by varying the head on the suction, rather than by varying the speed or throttling the discharge. This variable head on the suction of the boiler-feed pumps is obtained by varying the speed of the condensate pumps. The regulator which operates the speed control on the condensate pumps is actuated by an excess-pressure regulator, that is, this regulator holds the boiler-feedwater pressure at 50 lb. in excess of the boiler steam pressure. The boiler steam pressure for this regulator is taken directly from the saturated drums.

This system has the advantage that the condensers were purchased with a definite guarantee of oxygen content per liter, which it was believed is below the point where danger from corrosion or pitting in the steel-tube economizers or in the boilers can occur. It also lends itself to the elimination of elevated surge tanks, which are costly from a structural standpoint, and it tends to make the evaporator installation flexible, as there is no fixed point of temperature and pressure going to the high-heat-level condenser as is the case with an open-feedwater installation.

In order to supply the necessary reserve water capacity the area between the foundations in the boiler room has been enclosed, making them into concrete surge tanks. In case the water level rises in the condenser hotwells, showing an excess in the system, it is possible to open a valve on the discharge of the condensate pumps so that they will discharge into the surge tanks. If, however, the water level in the condenser hotwells falls, showing a deficiency of water in the system, a valve can be opened which admits water from the surge tanks into the top of the condensers. In this manner all water entering the system passes through the condenser. The two bleed points are at the fourth and seventh stages of the nine-stage turbine. (*Power Plant Engineering*, vol. 29, no. 20, Oct. 15, 1925, pp. 1034–1041, 12 figs., *d*)

Railroad Water Treatment

A SYMPOSIUM of three papers describing different methods of treatment. The first paper, entitled Lime and Soda Ash Method, is by O. T. Rees, Chief Chemist for the A. T. & S. F. Railway. The author believes that practically all of the most popular types of water-treating equipment have some objectionable feature, but that with proper supervision a good treatment may be obtained with any of them. The A. T. & S. F. Railroad has 134 plants now in operation and authority for 16 more. They are not all alike and no special or automatic proportioning device is used, the system being to know the amount of water being pumped and regulate the speed of the chemical pump so as to furnish the correct amount of chemicals. Some of the details of installation are described. The Roberts water motor is employed on 50 of the plants in existence as a proportioning device, practically all of the later plants being constructed to use the Roberts motor except where the entire plant is to be operated by electricity.

Navy compound as a method of treatment was described by R. S. Twogood, Assistant Engineer, Electric Department, Southern Pacific Company. The conclusion arrived at by the author is that the Navy method of boiler-water treatment will prevent pitting and scale formation. It permits of uniform individual boiler treatment. The first cost is usually less than $50. It puts the treating of the water in the hands of the men that are most interested in easy and good boiler operation. The cost of chemicals is fairly low.

The zeolite method was described by C. W. Sturdevant, Assistant Engineer of Tests, Southern Pacific Company. *The Journal of the Pacific Railway Club*, vol. 9, no. 5, Aug., 1925, pp. 5–39 including discussion, *dcp*)

Patents on Boilers at Hell Gate Station

THE question as to the validity of patents controlled by the Babcock & Wilcox Co. with reference to the case of the boilers at the Hell Gate Station was recently decided by Judge Knox of the U. S. District Court, New York City. These boilers were erected by the Springfield Boiler Co. and the Superheater Co., and the Babcock & Wilcox Co. sued them for infringement of certain claims in the patents to Bell, No. 1,141,520, and to Pratt, reissue No. 15,214.

From an extensive discussion of the claims in these patents and the history of the art, it would appear that some years ago the Babcock & Wilcox Co. built the Sewall boiler, which developed many troubles in tests and was never used commercially. Arthur D. Pratt, connected with the Babcock & Wilcox Co., then developed a boiler featured by a characteristic position of the superheater, but no boiler in accordance with the Pratt design has ever been built. Pratt, however, applied for a patent on his boiler in October, 1915. Then contracts were awarded to the Springfield Boiler Co. for the Hell Gate boiler installation, following which there was a reissue of the patent to Pratt.

The Court decided that while Pratt did patent the use of bent tubes in the superheater, he was entitled not to a reading of claims which would cover any kind of bent tubes, but only tubes bent in the particular manner specified by him, which was different from that employed in the Hell Gate boiler, and that, generally, the boiler described in the Pratt patent is substantially different from the boiler as installed at Hell Gate.

An interesting part of this decision is the discussion as to what constitutes a pass in a multiple-pass boiler. This is reproduced from the decision as follows:

> As bearing upon the question as to what constitutes a "pass" in a multiple-pass boiler, attention may be directed to Jacobus' patent No. 1,470,744, in which the advisory engineer of plaintiff points out a number of distinct advantages attributable to the non-obstruction by baffles of the lower bank of tubes. Not only does he do this, but he describes how, in the invention secured by his patent, "the gases" after being distributed ".... so that they contact with the entire length of the lowermost tubes, are directed forwardly by the roof baffle and are made to flow into the lower part of the first pass, after which they flow through progressively decreasing areas throughout the boilers....."
>
> To my mind the significance of this statement is that the first pass of Jacobus is substantially the first pass of Bell; and that in 1918, when the former asked for his patent, and when there was no pending litigation, there was no confusion as to what, in the opinion of this eminent authority, constituted a "pass" in the art of boiler construction. To paraphrase the words of the defendants' expert in defining the sense in which Bell used the term "pass," it is the portion of the boiler at the up-flow side of the inclined transverse baffle. That is the sense in which Jacobus used the term, and it is certain that the lower bank of tubes in the Jacobus patented boiler is not within his description of a "first pass." Some confirmation for the conclusion that in this art transverse passes are formed only by upright baffles, or by baffles and headers, is to be found in rejected claim No. 10 of Pratt patent No. 1,274,327. It specified that the upper group of tubes should be equipped with transverse baffles dividing the same into a plurality of passes beginning at the steam-intake ends of the tubes.

The case was decided in favor of the Springfield Boiler Co., but is, of course, subject to appeal by the plaintiff. (*Combustion*, vol. 13, no. 4, October, 1925, pp. 227–229, *g*)

Tests on a Bent-Tube Heine Boiler in Detroit

DATA of tests made on a stoker-equipped V-type boiler at the plant of the Hudson Motor Car Co. in Detroit for the purpose of determining the merits of the bent-tube boiler design. The tests were conducted by members of the engineering department of the Heine Boiler Co. and the unit used was a four-pass boiler 15 tubes deep, 20 ft. center to center of drums, 6285 sq. ft. heating surface. The boiler was designed for 180 lb. pressure and an operating pressure of 150 lb., and the stoker was a six-retort Westinghouse underfeed with 107.8 sq. ft. of projected grate area.

Four efficiency tests were run, these being at 99 per cent, 147 per cent, 183 per cent, and 228 per cent of rating. The first two tests were of 24 hr. duration, and the other two of 12 hr. duration. In addition, three short tests at low percentages of CO_2, namely, 7.4 per cent, 9.4 per cent, and 12.3 per cent, were run. The lower CO_2 tests were of 4 hr. duration only and the efficiency was calculated from a heat balance.

Curves in the original article show how the work was distributed in the different passes of the boiler. It should be particularly noted that the work done by the first pass of the boiler, that is, the first three tubes, amounts to approximately 78 per cent at rating, and decreases to approximately 68 per cent at 250 per cent of rating. All the steam formed in these first three tubes passes to the front drum, thence through the steam connectors into the middle drum, and finally through another set of connectors into the rear drum. On account of the length of the steam travel this 70 per cent of the steam generated in the first pass is said to have a fine opportunity to drop its entrained moisture.

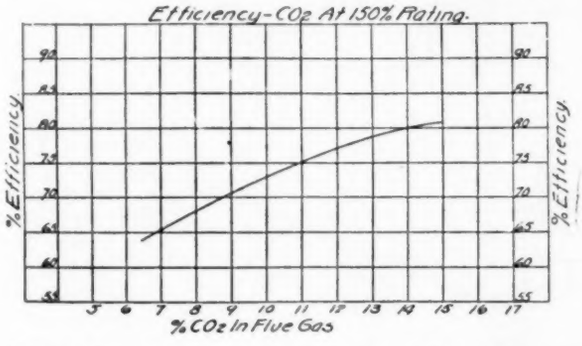


FIG. 3 OVERALL EFFICIENCY COMPARED WITH BOILER RATING

As regards draft loss through boiler and superheater when plotted against rating, it was found that this quantity amounts to 0.08 in. of water at 100 per cent of rating and increases in a curve whose exponent is 2.56 to 1.00 in. of water at 250 per cent of rating. This draft loss is considered quite low, even for a boiler of this type.

Tests for exit gas temperature at 14.5 per cent CO_2 plotted against rating would indicate that at 100 per cent rating the exit gas temperature is 455 deg. fahr., or approximately 90 deg. above saturated steam temperature. As the rating is increased the exit gas temperature increases in a curve whose exponent is 1.50 up to exit gas temperature of 700 deg. fahr., or 345 deg. fahr. above saturated-steam temperature at 250 per cent of rating. These exit gas temperatures are low for a bent-tube type of boiler, and indicate that the boiler may be operated at high efficiencies.

The relation between efficiency of boiler, superheater, and grate plotted against rating is shown by Fig. 3. At 100 per cent of rating the efficiency is approximately 81.5 per cent. This efficiency remains constant for a short distance; then, as the rating is increased, drops off more and more rapidly until at 250 per cent rating the efficiency is approximately 73.2 per cent. These efficiencies are remarkably high for a boiler of this type. In order to maintain this high efficiency, a high and uniform CO_2 must be maintained. When the CO_2 is allowed to decrease, there will be a corresponding decrease in efficiency as shown in Fig. 4.

Fig. 4 shows the relations between CO_2 and efficiency at a constant rating of 150 per cent. At the CO_2 of 14.5 per cent, carried throughout the efficiency test, the efficiency is 81.0 at 150 per cent of rating. As the CO_2 is decreased the efficiency decreases down to a value of approximately 66 per cent and 8 per cent CO_2.

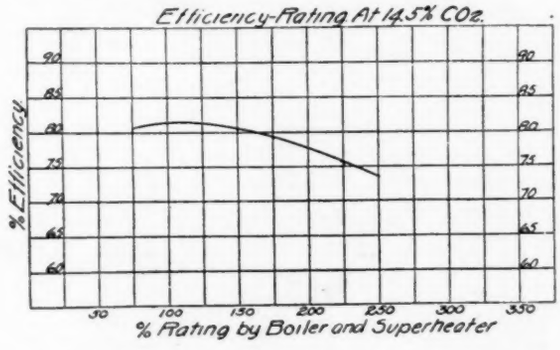
The success of the tests is due partly to the excellent performance of the stoker with which the operators were able to maintain a CO_2 of 14.5 per cent constantly throughout the test without carbon monoxide being detected. The combustible in the ash throughout the test varied approximately 20 per cent to 26 per cent. This ashpit loss might be considered a little high at the lower ratings, but is acceptable at the higher ratings. (*Power Plant Engineering*, vol. 29, no. 20, Oct. 15, 1925, pp. 1049–1051, 8 figs., *e*)

RAILROAD ENGINEERING

Baldwin Diesel-Electric Locomotive

DESCRIPTION of a locomotive which has been completed and tried in service. It is driven by a Knudsen Diesel engine capable of developing 1000 hp. (For a description of the Knudsen engine see MECHANICAL ENGINEERING, vol. 45, no. 10, Oct., 1923, p. 593, and vol. 47, no. 6, June, 1925, p. 503.)

The rated maximum tractive force of the Baldwin locomotive is 52,200 lb., the oil engine having a rated capacity of 1000 hp. The total weight of the locomotive is 275,000 lb., of which 180,000 lb. is carried on the driving wheels. The total length over the couplers is 52 ft. 1¾ in. The locomotive has a total wheelbase of 38 ft. 4 in. and a rigid wheelbase of 12 ft. 8 in. The electric transmission consists of four Westinghouse type 353-D-3 standard railroad type self-ventilating 200-hp. motors which are geared to the driving axles through flexible gearing. Power is furnished to these motors by a Westinghouse self-ventilating direct-current generator and exciter directly connected to the engine.



[FIG. 4 OVERALL EFFICIENCY WITH GIVEN LOAD COMPARED WITH VARIATION IN CO_2

A feature in the design of this locomotive is the arrangement of the spring rigging, which has been patented by the builder. Two springs are placed over each box, one on the inside and one on the outside of the frame, each resting directly on top of the journal box and connected with each other by short cross-equalizers at each fixed attachment to the frames. These equalizers allow for any variation in the height or deflection of the two springs which act together. Placing the spring alongside of instead of over the top of the frame, as would be required by the usual arrangement of one spring for each journal box, permits the lowering of the center of gravity of the locomotive at least six inches, and also permits a corresponding increase in the headroom in the cab.

The locomotive has for some time been in service on the Reading Railroad, part of the time in road freight service and part of the time in yard service. In both services the locomotive has given a good account of itself, particularly in heavy switching service. It has handled 1000-ton trains from Reading to Tamaqua, a distance of approximately 40 miles, about three-fourths of which is upgrade at the rate of about 0.7 per cent, with an average of 3.3 gal. of fuel oil per 1000 gross ton-miles. It has moved these trains over the grade at a speed of approximately 16 m.p.h. On

the runs in the reverse direction with 2000-ton trains the fuel consumption averaged 1 gal. per 1000 gross ton-miles. The block tests of the engine indicate a fuel consumption of 0.40 gal. per hp-hr. at full load, increasing to 0.45 gal. per hp-hr. at part load. The engine developed a maximum crankshaft speed of 480 r.p.m. (*Railway Age*, vol. 79, no. 15, Oct. 10, 1925, pp. 645–648, illustrated *d*)

REFRIGERATING MACHINERY

Flywheel Requirements for Unbalanced Air and Ammonia Compressors

IF A TWO-CYLINDER double-acting single-stage compressor is built with exactly duplicate cylinders, if the weights of reciprocating parts are equal, the crankcase and connecting rods are the same and the suction and discharge pressures are exactly alike on all cylinder ends, the compressor can be said to be balanced. There are a number of factors, however, which might cause unbalance. Thus, if the suction pressure on the end of one cylinder is changed while the remainder of the compressor stays the same, the compressor is unbalanced. The same happens when one piston is heavier than the other or when the two cylinders operate from different ammonia systems in the case of an ammonia compressor, etc.

There are often advantages in upsetting the ideal balance of the unit to obtain other desirable results such as the advantages of compounding (compound compressors seldom have equal pistons), the utilization of split suctions as in an ice-cream plant or an ice and cold-storage plant, the saving by operating at reduced capacity when full capacity is not needed, and the like.

The use of unbalanced compressors must, however, be taken into consideration in the matter of flywheel design. Previous work by several investigators, in particular Stevenson, has developed the theory of the subject. The present author gives a short method of calculation of a character that may be used for practical purposes, and also methods of tests. For purposes of calculation, in particular determining the power or current pulsation for any compressor unit, he gives a series of curves. To use them is necessary to calculate the values of certain parameters from the characteristics of the unit under consideration, and find a curve on one of the charts which satisfies all of the parameters. From this curve the pulsation may be read.

Flywheels on compressors may be tested by means of an oscillograph, but this method is difficult and expensive. The author suggests, however, a comparatively simple method which, while not highly precise, is sufficiently delicate for practical purposes. (C. W. Cutler, Industrial Engineering Department, General Electric Co., Schenectady, N. Y., in *Refrigerating Engineering*, vol. 12, no. 3, Sept., 1925, pp. 75–87, 22 figs., *peA*)

STEAM ENGINEERING

The New Large Brown-Boveri Turbines

THESE turbines are of the "reaction" type in three cylinders for normal heat drops (Fig. 5). The first and second stages work on the impulse principle, but with a certain amount of reaction. The cylinders are arranged so that the steam flows in opposite directions in the intermediate and high-pressure portions, and the diameters of the drums are so chosen that the axial thrusts are balanced as much as possible. Dummy pistons can therefore be dispensed with. For the larger outputs and the usual vacuums the low-pressure cylinder is, as a rule, double-ended with single admission, so that axial thrust is eliminated in this case also.

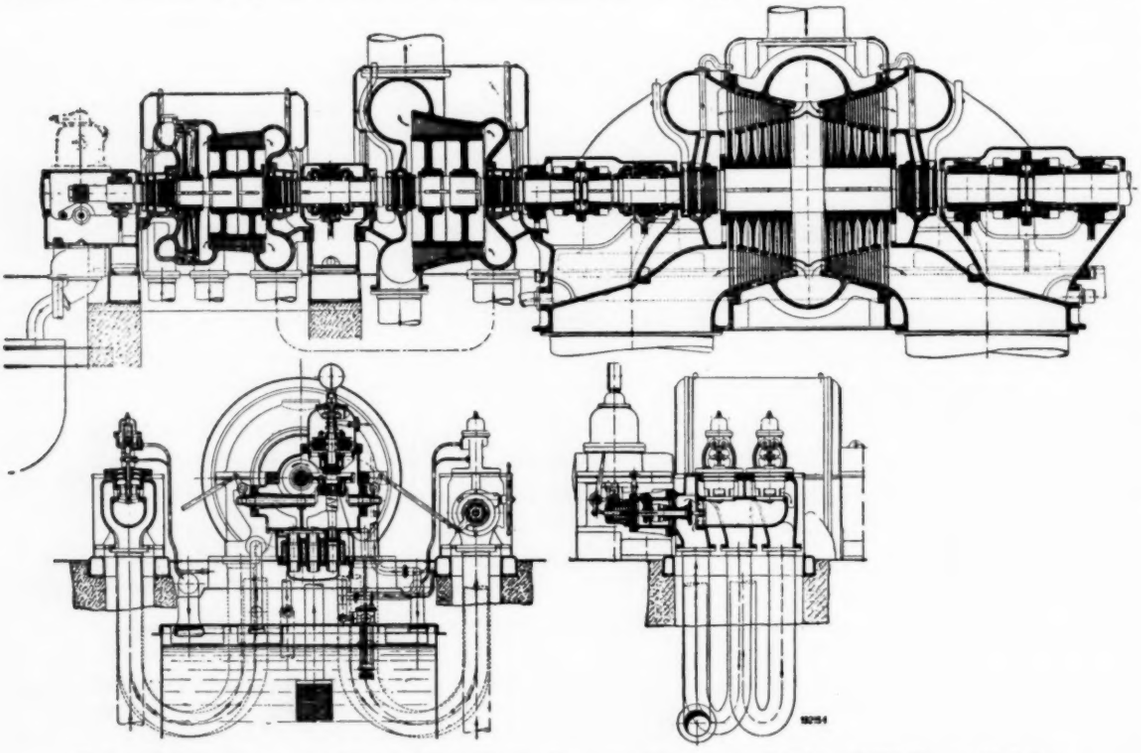


FIG. 5 SECTION THROUGH A BROWN-BOVERI THREE-CYLINDER TURBINE OF 25,000 TO 50,000 KW. AT 1500 R.P.M.

The blades are fixed in position by an enlargement of the foot into a T-form produced by a pressing process. The projections are held by spacing pieces which fit into grooves in the disk. The free ends of the high-pressure and intermediate blading are sharpened so that radial blade clearances can be made very small. The low-pressure blading is mounted on disks and the leakage of steam over the ends of the blades is taken care of by a special arrangement, the essential feature of which (Fig. 6) is that the shroud ring of each successive row of blading projects radially beyond the foot of the preceding row so that they act in a similar manner to the slates of a roof, the steam flowing across the gap without loss.

The main part of the axial thrust is eliminated in the manner described above. Any thrust that may remain unbalanced is taken up by two heavy thrust bearings which are combined with the journal bearings.

The admission of the steam is controlled by four regulating valves housed in two separate casings. On full load, two of these valves are completely open, admitting steam to the complete circumference of the first impulse wheel. On half-load, one valve is open with half admission to the first impulse wheel; on overload, steam flows through the remaining two valves directly into the chambers between the impulse wheels and the reaction blading; on full overload, the steam is not throttled, so that there is no drop in pressure across the impulse stages, which consequently run light. As a result of the use of the impulse principle for the first stages, the distribution of the axial thrust remains unaltered. The regulating valves are operated on the Brown-Boveri oil-pressure, steam-control system.

The superiority of reaction turbines to those working on the

impulse principle, both as regards efficiency and constructional simplicity, has in certain quarters occasioned undue emphasis to be placed upon the relatively small blade clearances and the blade-tip losses inseparable from reaction turbines. In fact, some statements which have been made give the impression that if reaction turbines were not made with clearances so small as to constitute a permanent danger, it would be impossible to attain a reasonably good efficiency. In this connection it should be mentioned that the chief reason for such blading accidents as occurred with Parsons turbines in the early days was the excessive length of the drums and the construction of the casing with cast-on longitudinal strengthening ribs and equalizing steam channels; thus, the casing was easily distorted on account of uneven expansion, resulting in stripping the blades. Further the method of fixing the blades by calking with bronze wedges expanded to a greater extent than the drum, so that they gradually worked loose and, being able to withstand the centrifugal force, the blades became displaced and were stripped.

By making the cylinder short and of simple form, free from cast-on projections, and by dividing the turbine into three cylinders, thus decreasing the temperature drop per cylinder; distortion of the kind described is entirely obviated. The drums run in bearings

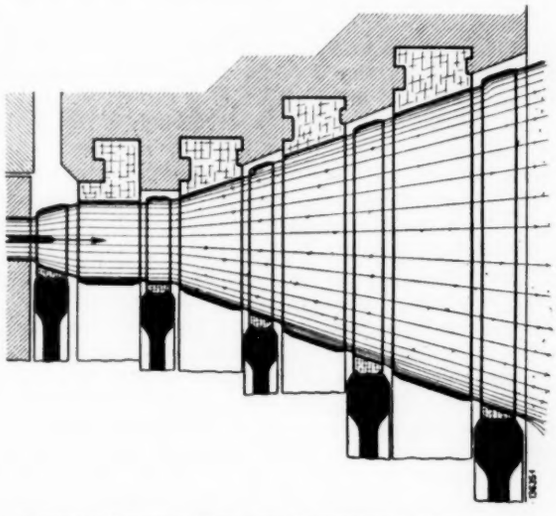


FIG. 6 DIAGRAM SHOWING HOW THE CLEARANCE LOSSES ARE MINIMIZED BY A SPECIAL ARRANGEMENT OF SHROUD RINGS

arranged close together, and the blades are fixed extremely firmly. With regard to the expansion when the turbine is heating up and the danger to which this subjects the blading, it should be mentioned that, when rapidly heated up, the motor of a disk-type turbine expands more rapidly, the area of the rotor exposed to the steam being very many times greater than the internal surface of the casing. With the high-pressure cylinder of the new reaction turbine there is practically no difference in the rates of expansion of the rotor and casing, as both have almost the same surface exposed to the steam and the mass of the rotor is very much greater.

Further, the fact that the drum revolves makes very little difference to the rate at which it becomes hot, whereas this is of great importance in the case of disk-type rotors. Even should the ends of the blades come in contact with the drum or cylinder, experience has shown that no danger is to be feared as the blade tips are sharpened so that they wear down very easily.

Within one year fourteen of these large turbines have been sold, representing a total power of 350,000 kw. (W. G. Noack in *The Brown-Boveri Review*, vol. 12, no. 10, Oct., 1925, pp. 199–202, 4 figs., *d*)

VARIA

A Coöperative Course in Electrical Engineering at the Massachusetts Institute of Technology

WITH the opening of the fall term, the Massachusetts Institute of Technology took another step in carrying out its policy of maintaining the closest possible contact with the industries of the country. Arrangements have been completed with the Bell Telephone System by which a limited number of students in electrical engineering will be given an opportunity to get thorough first-hand knowledge of the manufacture, operation, and development of the most modern electrical systems of communication, including wire and wireless telephony and telegraphy.

By this new arrangement a carefully selected group of students who have successfully completed the first two years of the regular course in electrical engineering at the institute, or the equivalent at other institutions, will be sent to New York. For four months they will be under the direction of the Bell Telephone System. During part of this time they will be put to work in the Western Electric Company's plant at Kearny, N. J., learning the actual details in the manufacture of telephone appliances. The remainder of the time will be spent in the work of installing and conditioning telephone switchboards in the vicinity of New York City.

During this time the students are on the payroll of the Bell System and must turn out their day's work like other workmen, but as fast as they master one job they are transferred to another. The new course requires these students to attend regular institute classes while they are not on the practical assignment, and since they can not come to the institute, the institute goes to them by maintaining an instructing staff in New York. The class hours will be in the evening in order not to interfere with the practical work. The subject-matter will be amost equally divided between electrical theory and such cultural subjects as the writing and delivering of technical papers and reports, and the study of contemporary English literature and drama.

At the end of the four months this group of students returns to the Massachusetts Institute of Technology in time to join their schoolmates in starting the second term's work, and another group takes their place in New York. They will spend the alternate terms at the institute and on the job in New York, where they will complete their practical experience by doing actual telephone operating in the various plants of the New York Telephone Company and getting familiar with the technical and practical problems of maintaining plant and equipment. (*Science*, New Series, vol. 62, no 1607, Oct. 16, 1925, p. 345, *g*)

WELDING (Papers read at Boston meeting of the American Welding Society)

Gas Welding of Power-Plant Piping in Shop and Field

IN THE opinion of the author, who is chief engineer of the heating, power, and industrial-piping division of the Grinnell Company, only one thing has intervened to keep all-welded pipe lines in power-plant work from being the rule rather than the exception as at present, and that is the importance of the human factor in welding. Because of that human factor no weld can be better than its welder. In welding work the individual workman is more responsible for the job than in any other similar type of work.

Efforts have been made and are still being made to counterbalance this dependence on reliable workmanship by the design of various more or less elaborate types of weld. The author does not believe that design can make up for possible poor workmanship, and while in his own work some of these elaborately designed welded joints have been made, his experience—dating back to 1910—is that the plain butt weld properly made is as strong or stronger than the base material itself.

At the same time, welding of power-plant piping has many advantages, and the author states them extensively. The first advantage is lower cost; for example, a certain header if made by welding would cost $332, while the same header made with lap-joint flanges and extra heavy cast-steel fittings would cost $1034. There is also a great saving in weight with welding. The expense of insulating flanges is reduced, there is a saving in weight of the pipe itself, and finally, elimination of special steel castings, which are apt to prove defective and thus materially delay the completion of a job. The maintenance cost is less, because of the comparative absence of leaky joints.

The author next discusses the materials, tools, methods of construction, and tests of welded joints, and makes a suggestion that those interested in welding should see to it that this process is properly considered in working out the proposed A.S.M.E. code for

pressure piping. In fact, he states that when that code for pressure piping becomes a reality, welding will go forward or sink below its present level in proportion to the way that code treats welding. (A. W. Moulder in *Journal of the American Welding Society*, vol. 4, no. 10, Oct., 1925, pp. 5–23, 15 figs., *g*)

Welding All-Steel Automobile Bodies

THE AUTHOR deals chiefly with the practice of the Edward G. Budd Manufacturing Company, where he occupies the position of superintendent. In light-gage sheet-metal fabrication, riveting was formerly used almost exclusively, but as a means of assembly it caused much difficulty. Electric spot welding has replaced riveting because the welds are strong, the production is large, the cost lower, and operation is cleaner than in riveting, while at the same time the capital investment in tools and the maintenance cost have undergone a notable reduction.

During the early days of electrically spot welding sheet metal much difficulty was encountered due to the failure of manufacturers of sheet metal to hold sheets to a uniform gage, but considerable improvement in this direction has been made and welding machines have been designed with controls which make it possible to take care of this difficulty.

In the design of all-steel automobile bodies much stress is laid on the necessity to secure the necessary rigidity with a minimum number of pieces so as to facilitate the ready assembly in the jigs and fixtures for welding. In a welded joint there must be no surface irregularities such as blowholes in seams or improperly closed joints, as these would produce a blow or blister in baking. The surface must be absolutely smooth, without depressions or cavities in which more than the standard thickness of enamel can flow, so that lacquers and clear varnishes can be applied with the minimum amount of labor.

The amount of welding required on open-type bodies is as follows: 1000 to 1100 electric spot welds, 70 to 80 in. of acetylene-gas welding, and 10 to 12 in. of metallic-arc welding. On the full-vision all-steel sedan bodies the average amounts of welding is still greater.

The author discusses the methods used, and gives standard qualifications for apprentices and instructions to electric spot-welding operators. He also describes the standard spot-welding practice and briefly touches on the strength of spot welds as compared with riveted joints. In this latter connection he comes to the conclusion that there is no substantial difference between the two.

If two thin pieces of metal and two thick pieces of metal be riveted with rivets of the same size, there is a certain thickness of metal below which all failures will arise through the tearing of the sheet and above which failures will be due to the shearing of the rivet. The same is true of spot welds if the area of the spot weld be held constant; on the other hand, when the section of the rivet is small and that of the sheet large, it is always the rivet that fails—and the same holds good for a weld. (J. W. Meadowcroft in *Journal of the American Welding Society*, vol. 4, no. 10, Oct., 1925, pp. 43–57, *d*)

Thermit-Welding Developments

THE principle of thermit welding is very simple and quite well known. It depends on the ability of powdered aluminum to reduce oxides of metals and to produce in so doing a temperature so high that the resultant metal is not only welded but in many cases—as, for example, with iron—is highly superheated. In the original thermit-welding practice a two-part dry-sand mold previously prepared on wooden patterns was clamped on to the section being welded after the section had been warmed slightly to eliminate surface moisture. Then the thermit steel was poured into the mold, sufficient material being used to bring the parts to the welding heat and fuse them together. The quality of this weld was not good. Preheating of the sections to be welded to a bright red was then introduced. This resulted in an improvement in the quality of thermit welds, but still did not make them uniformly good, as quite often blowholes were found in the weld.

A careful investigation has indicated that the origin of these blowholes lay in the evolution of gas from the mold which was made of materials that stood up well under the action of ordinary steel, but not under that of steel superheated to the degree used in thermit welding. A remedy for this was found in the selection of the best clays for use in the mold and such a design of molding material as would give the maximum porosity after baking and thus provide ways of escape for the gas through the mold. (With the dense molds previously in use, the easiest way for the gas to escape was through the metal.)

The next development was the so-called "center-pour" weld, by means of which the amount of thermit steel was cut about in half. Still a trouble remained, namely, an internal difficulty in the weld called by welders a "cleavage plane." This consisted in an existence of an area just below the axis of the piece on a vertical plane running through the middle of the gap between the sections to be welded where the metal had been torn apart during solidification and around which the crystals had been very much overstrained or where the metal was only overstrained without being actually torn apart.

An investigation showed that this was due to the manner of freezing of a thermit weld which was opposite to what took place in an ordinary steel casting; namely, the freezing started at the center of the weld, across the gap between the sections practically on the axes of the pieces, and progressed from this point outward. A remedy for this difficulty was found in decreasing the gap between the ends to a minimum and at the same time decreasing the excess heat in the collar and in the riser so that in this way the ratio between the heat on the outside and the heat at the axes would be more nearly uniform. This not only eliminated the cleavage plane but reduced again the amount of thermit to be used. The latter is important not only because it produces a saving in material, but because it permits effecting a very material saving in the cost of crucibles in which the original reaction is carried out. It would appear that the cost of crucibles is a serious item of cost in thermit welding, and rapidly rises with the size of the crucible.

In this latter connection a new development is about ready to be placed on the market. The ordinary crucible was made of graphite and lined with magnesite, and its life was comparatively short, being in the case of small crucibles 40 to 50 reactions, but in the case of large crucibles the lining lasted only for four or five reactions. Now in the thermit reaction aluminum takes up the oxygen from the oxide of the metal, say, iron, and produces aluminum oxide on one hand and metallic iron on the other. Aluminum oxide is, however, fused alumina, one of the best refractories known, and the Thermit Welding Company has developed steel crucibles in which the thickness of the wall is so selected that it will cause a layer of alumina to freeze on its inner surface, which will prevent the crucible wall itself from being washed away. The crucible so designed without any artificial lining at all is expected to be practically everlasting. Such crucibles have been in use for over 500 reactions and are just as good today as when they were made.

In conclusion, the author predicts that the future will show that, in the thermit reaction, steels can be produced which will have very unexpected properties. Certainly, in this mixture of practically pure aluminum and practically pure iron oxide we have a basis on which to work which is very different from that which starts with the very impure materials which enter the blast furnaces and which are gradually purified to satisfy the needs of commerce. We have already reached points in thermit steels where, without work or heat treatment, the cast thermit steel will exhibit such properties as 110,000 lb. per sq. in. ultimate strength with 2 per cent or 3 per cent elongation in 2 in., or the other extreme of an ultimate strength of 55,000 lb. per sq. in. with 40 per cent elongation in 2 in.; and these cast steels are so pure that they invariably fracture through grains instead of along grain boundaries as is the case with ordinary cast steels, so that a thermit weld must not be considered as a cast joint in the middle of forged steel pieces because this thermit cast steel has all of the physical properties of the forging and resists shock just as easily. (J. H. Deppeler, Chief Engineer, Thermit Department, Metal and Thermit Corporation, in *The Journal of the American Welding Society*, vol. 4, no. 10, Oct., 1925, pp. 58–64, *ed*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Test Code on Instruments and Apparatus

Preliminary Draft of Chapter 3, Temperature Measurement, Section 1—General

THE Main Committee on Power Test Codes takes pleasure in presenting to the members of the Society for criticism and comment Chapter 3 of the Code on Instruments and Apparatus, dealing with Temperature-Measurement Tests. The Individual Committee which developed this draft consists of Messrs. C. F. Hirshfeld, Chairman, C. M. Allen, E. G. Bailey, L. J. Briggs, W. A. Carter, J. D. Davis, R. E. Dillon, F. M. Farmer, J. J. Flather, J. B. Grumbein, O. Monnett, S. A. Moss, R. J. S. Pigott, E. B. Ricketts, S. W. Sparrow.

Code No. 19 on Instruments and Apparatus will consist of twenty-two chapters dealing with the following subjects: (1) General Considerations,[1] (2) Pressure Measurement (7 sections), (3) Temperature Measurement (11 sections), (4) Head Measurement, (5) Quantity of Material, (6) Electrical Measurements, (7) Mechanical Power, (8) Indicated Horsepower, (9) Heat of Combustion, (10) Chemical Composition, (11) Quality of Steam, (12) Time, (13) Speed, (14) Mechanical Measurements, (15) Surface Area, (16) Density, (17) Viscosity, (18) Humidity, (19) Concentration of Dilute Solutions, (20) Smoke, (21) Condenser Leakage,[2] (22) Hydraulic Power Plants.

The Individual Committee, the Main Committee, and the Society will welcome suggestions for corrections or additions to this draft from those who are especially interested in this subject. These comments should be addressed to the Chairman of the Committee in care of The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y.

GENERAL

1 Measurement of temperature is generally supposed to be one of the simplest and most accurate measurements performed in engineering. This is decidedly a misconception. Accurate temperature measurement under some conditions is impossible with our present knowledge. Under many of the conditions met in power tests the desired accuracy in the measurement of temperature can be obtained only by observance of suitable precautions in the installation and use of temperature-measuring instruments, and in the interpretation of the results obtained with them. In some cases an arbitrarily standardized method is prescribed in the code, and it is to be followed in making temperature measurements under such conditions.

2 Many of the instruments available for temperature measurement are capable of indicating temperature far more accurately than required in most of the tests considered in the code. The difficulty comes in the use of the instruments, due either to the manner in which they are installed or the manner in which they are used after installation. Specific directions and precautions in the use of the various types of temperature-measuring instruments are given in later paragraphs devoted to the individual instruments. Specific directions for the measurement of temperature of certain materials such as superheated steam, flue gas, exhaust gas from internal-combustion engines, etc., are given under individual headings at the end of this chapter. Certain general considerations which are of wide application are treated here.

3 One of the principal sources of error in temperature measurement is the natural tendency toward temperature equalization. This tendency which causes the flow of heat from regions of higher to regions of lower temperature must always be borne in mind, and the effect of any possible flow on the reading of the instrument must be determined in some way before any assurance of accuracy can be had. Examples of the ways in which this tendency may influence results are given in the paragraphs immediately following.

4 Assume a thermometer well inserted in the wall of a pipe as shown in Fig. 1, and assume that some material, such as superheated steam or a highly heated gas, is flowing in the pipe. It is commonly assumed that the thermometer well acquires the temperature of the flowing material and therefore that, if it is partly filled with liquid and a thermometer is inserted therein, a correct measurement of the temperature of the flowing material will be obtained. As a matter of fact, with temperatures of 500 to 600 deg. fahr. inside the pipe and temperatures of 50 to 100 deg. fahr. outside the pipe an error varying from 1 or 2 deg. to as much as 40 or 50 deg. may exist, the thermometer indicating too low a temperature. This results from the fact that the thermometer well serves to carry heat from the material within the pipe to the external atmosphere and surroundings. Heat may be lost from the upper end of the well by transfer to the pipe wall, by transfer to the atmosphere in contact with the projecting end, and by radiation to surrounding objects at a lower temperature. All such heat must come from the material whose temperature is being measured, and in order to cause a flow of heat from this material to the well immersed in it there must be a temperature difference. That is, the metal of the well must always be of a lower temperature than the material in which it is immersed. The magnitude of the temperature difference will depend upon the amount of heat flowing (i.e., the amount dissipated by the outer end of the well), the heat-transfer coefficient for the material in question, and the extent of the contact surface. The case is somewhat analogous to that of a water-tube boiler in which engineers expect to find differences of hundreds of degrees between the temperature of gases and the temperature of metal walls immersed in those gases.

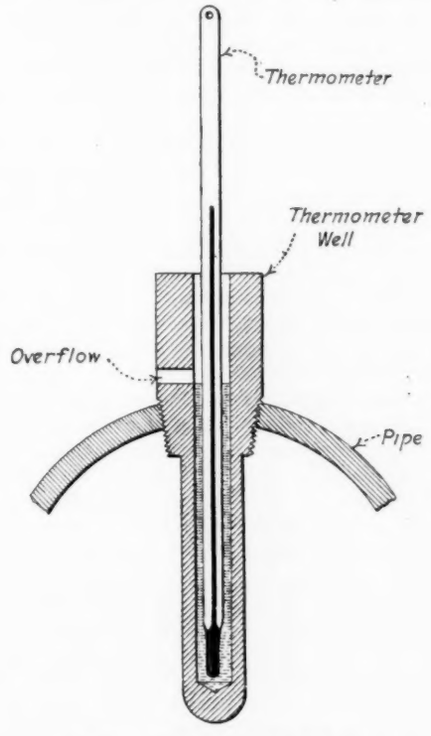


FIG. 1 PLAIN MERCURY WELL

5 Another example of the possibility of error resulting from heat flow is furnished by thermocouples. Assume, for example, a thermocouple contained in a metallic protecting tube which projects into a vessel, duct, or pipe containing material at a temperature lower than the surroundings. Heat will flow along the leads of the couple and along the protecting tube from the surroundings to the material whose temperature is being measured. Quite obviously, the thermocouple may be expected to have a temperature higher than that of the material being measured, and therefore the temperature indicated will be in error. Errors of significant magnitude are easily introduced in this way.

6 Or assume a bare thermocouple, with the leads protected by beads or other segmental insulation, and assume that the thermocouple is immersed in hot gases in such a way that the leads pass

[1] This Chapter was published in the February, 1923, issue of MECHANICAL ENGINEERING.

[2] This chapter was published in the November, 1925, issue of MECHANICAL ENGINEERING.

through layers or strata at lower temperatures. In this case heat will flow away from the hot junction of the couple and the temperature indication will be too low.

7 Neglect to consider mass flow when measuring the average temperature of fluids flowing in a conduit may result in an error of another nature. As an example, assume that it is desired to determine the average temperature of hot gases flowing in a horizontal direction through a flue of large cross-section, say, 10 ft. by 10 ft. Assume that preliminary tests have shown that there is quite a variation in temperature of gas between different elevations in the flue and that the engineer has decided to obtain the average temperature by stringing a wire back and forth across the section of the flue and using this wire as a resistance thermometer. This would seem at first sight to meet all the requirements, but the possibility of error is very large, indeed. Assuming that the wire does correctly average the temperature over the cross-section, an assumption open to serious question, there is still a large error possible. In all probability the higher temperatures will be found at the top of the flue, and it may be that the connections are such that the velocity of gases at the top of the flue will be much greater than that of gases at the bottom. The average temperature of the gases flowing through the flue will under such conditions be higher than the average temperature of the cross-section, if mass flow is not taken into account.

8 Or again, assume that the temperature of the gases leaving the boiler is to be determined, and that because of the width of the damper it is decided to make the measurement by installing three thermocouples. Assume further that the rectangle just below the damper is imagined as divided into three shorter rectangles and that one thermocouple is placed at the center of each of these shorter rectangles. Even if the thermocouple gives the correct temperature of the gases flowing past it, there is still no assurance that each couple gives the average temperature of all gases flowing through the area which it is supposed to care for, nor is there any assurance that if it does, equal masses of gas flow through all these areas so that an average of the indications of the three thermocouples is really the average temperature of the gases. Actual measurements show that with properly regulated fires and with baffles in good condition it is possible to have temperature differences as high as 70 or more degrees fahrenheit between the gases at the center of length of the damper opening and gases near the ends of the damper openings. Little is known about mass flow, but it is reasonable to suppose it is greatest at the center with other things equal. The magnitude of the error which may result from neglecting the effect of mass flow can not be determined until information regarding variation of flow is available. However, it seems reasonable to suppose that errors of between 10 and 20 deg. fahr. in the average flue-gas temperature are well within the possibilities with such methods of measurement. The folly of using instruments and methods capable of determining temperatures within 1 deg. fahr. and neglecting possible errors of the magnitude indicated is obvious.

9 Another source of error in the measurement of temperature during a test is due to failure to take account of a variable rate of flow of the material, the temperature of which is being measured. As an example, assume that the average temperature of the feedwater entering a boiler is to be measured during a boiler test, and that the feed pump is practically shut down during the periods that the fires are being cleaned. Obviously, the measuring of the temperature of the feedwater at stated intervals of time will not give data for determining the average temperature of the water entering the boiler, if the water temperature is greatly different at low rates of flow from what it is under normal conditions. In such a case the temperature should be measured every time that a stated amount of water has passed a certain point in the feed system, such as once every time or every second time that the weighing tanks at the feed-pump section are emptied.

10 Radiation of heat between bodies at different temperatures is a prolific source of error. It is quite commonly assumed that a temperature-measuring device immersed in a medium whose temperature is to be measured will be, at least, very nearly at that temperature. However, if there are any bodies in the neighborhood at higher or at lower temperatures the probabilities are all against the correctness of such an assumption. For example, if a gaseous material is being heated by allowing it to flow through a tube with walls at a temperature higher than that of the material, a thermocouple or other temperature-measuring device immersed in the flowing gas may actually be at a temperature higher than that of the gas by virtue of heat radiated to it by the hot walls of the tube. Or if a thermocouple is used to measure the temperature of products of combustion flowing through a boiler and is so located that it can "see" the heating surface of the boiler, it will be at a lower temperature than the gases. Experiment shows that radiation to the colder heating surfaces of a boiler may cause a thermocouple to indicate temperatures as much as 150 deg. fahr. too low when immersed in flue gases at a temperature of the order of 600 deg. fahr.

11 It is obvious that accurate temperature measurement depends very largely upon correct methods of application of the instruments. As a corollary, the accuracy of any test which depends upon a temperature measurement is not determined when only a proper study of the accuracy of the temperature-measuring instrument has been made; a study of the accuracy attainable under the conditions of use is also necessary. The latter study requires the calibration of the instrument under conditions duplicating those of service. As an example, assume that an engraved-stem thermometer is under consideration. In calibrating the instrument it should be in the same thermometer well that is to be used during its service, or an identical one used, and the exact conditions of stem exposure and temperature of surrounding air should be duplicated.

INSTRUMENTS AND APPARATUS AVAILABLE FOR MEASURING TEMPERATURE

12 It is customary to call certain types of temperature-measuring instruments "thermometers" and others "pyrometers," the latter term being employed ordinarily for instruments adapted to use in measuring high temperature. There is no sharp distinction, however. The following types are available for use under appropriate conditions:

(*a*) Glass thermometers, with mercury, alcohol, pentane, or other organic liquids
(*b*) Pressure-gage thermometers, with vapors or liquids as the actuating fluids. There are two classes of these thermometers: (1) the vapor-pressure type partially filled with liquid ether, sulphur dioxide, ethyl, chloride, methyl chloride, etc.; and (2) those completely filled with a liquid or a gas, such as mercury, alcohol, nitrogen, etc. Instruments of the first type have scales that are made up of non-uniform divisions, while instruments of the second type have uniformly divided scales
(*c*) Differential-expansion thermometers or pyrometers in which the differential expansion of two solids is used as an indication of the temperature
(*d*) Electrical-resistance thermometers, with which temperature is determined by measuring the resistance of a calibrated wire
(*e*) Thermocouple pyrometers, or pyrometers in which the electromotive force set up at the junction of two dissimilar metals is used as an indication of temperature
(*f*) Optical pyrometers, with which temperature is determined by matching the luminosity of the hot body with that of a calibrated source or by other means which utilize the visible radiation emitted from a hot body
(*g*) Radiation pyrometers, with which temperature is determined by absorbing radiation of all wave lengths upon a small body and determining the temperature of the source by the temperature attained by the absorber
(*h*) Fusion pyrometers, with which temperature is determined by noting which of a series of materials with graduated fusion temperatures melt or soften when exposed to the temperature under investigation
(*i*) Calorimetric pyrometers, with which temperature is determined by noting the quantity of heat removed in bringing a body of known thermal capacity from the temperature to be measured to some lower known temperature
(*j*) Color-temperature charts, with which temperature is estimated by comparing the color of a luminous hot body with colors given on the chart.

13 The range and the accuracy obtainable with good commercial temperature-measuring instruments, when properly installed and used, are indicated in the following table.

Type	Range, deg. fahr.	Accuracy, deg. fahr.
(*a*) Glass Thermometers:		
Ordinary glass, mercury-filled	−38 to 575	1 to 2
Jena glass, mercury and nitrogen-filled	−38 to 1000	2 to 10
Quartz glass, mercury and nitrogen-filled	−38 to 1000	2 to 10
Ordinary glass, alcohol-filled	−100 to +100	0.5 to 2
Ordinary glass, pentane-filled	−300 to +70	0.5 to 2

Type	Range, deg. fahr.	Accuracy, deg. fahr.
(*b*) **Pressure-Gage Thermometers:**		
Vapor-Pressure Type:		
Alcohol-filled	200 to 400	2 to 10
Ether-filled	100 to 300	2 to 10
Sulphur-dioxide-filled	20 to 250	2 to 10
Liquid-Filled or Gas-Filled Type:		
Alcohol-filled	−50 to 300	2 to 10
Mercury-filled	−38 to 1000	2 to 10
Nitrogen-filled	−200 to 1000	2 to 10
(*c*) Differential Expansion Thermometer	300 to 1000	Uncertain
(*d*) Electrical Resistance Thermometer	−300 to 1800	Depends upon indicating instrument. 0.001° to 10°
(*e*) Thermocouple Pyrometers:		Depends upon indicating instrument. 0.02° to 20°
Base metal	−300 to +2000	
Rare-metal	0 to 2800	Depends upon indicating instrument. 0.1 to 20°
(*f*) Optical Pyrometers	1100 up	5 to 10 for black-body conditions
(*g*) Radiation Pyrometers	300 up	20 to 30 for black-body conditions
(*h*) Fusion Pyrometers	1100 to 3600	20 in best makes
(*i*) Calorimetric Devices	100 to 2500	Uncertain
(*j*) Color-Temperature Charts	800 to 2900	Uncertain

INSTALLATION

14 Details of installation applying specifically to given types of instruments are treated under these types. Certain general considerations are given here.

15 The "bulb" or sensitive element in those types requiring immersion in the material whose temperature is to be measured must be so located as to acquire and maintain as nearly as possible the temperature of the material under consideration. When the material in which it is immersed is substantially at rest, care must be taken to insure that the material in contact with the thermometer has the same temperature as the main body of the substance; as for example, by stirring a liquid before reading the temperature. When the material is in motion the possibility of stratification or of stagnant portions must always be considered in choosing the location and method of installation of the bulb.

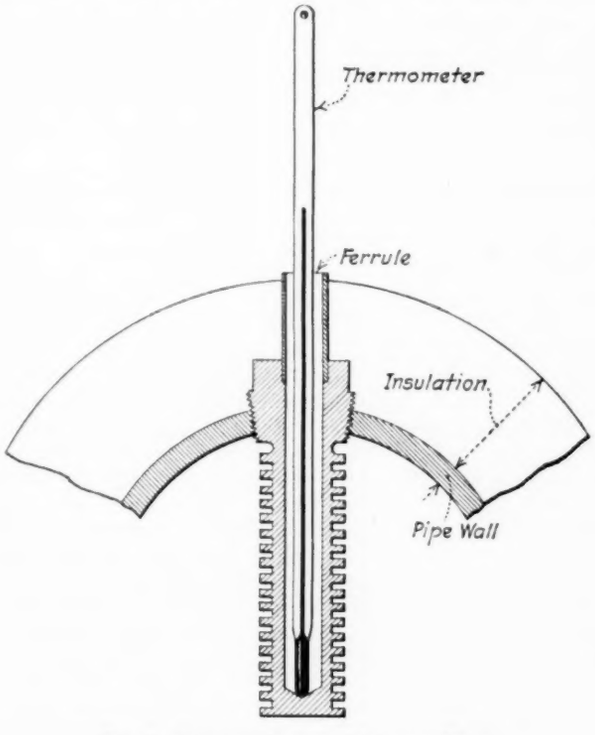


FIG. 2 IMPROVED FINNED MERCURY WELL

16 Under all conditions, methods which do not involve the use of thermometer wells between medium and instrument are to be preferred. Unfortunately they are not always possible under conditions governing the making of power tests covered in this code. When thermometer wells are used the following precautions must be observed, particularly when the temperature being measured differs greatly, say, 50 deg. or more, from that of the surroundings:

(*a*) The part of the well projecting beyond the container must be as small as possible so as to eliminate heat transfer to or from surroundings.

(*b*) The exposed parts of the well should be covered with thermal insulating material of a kind appropriate to the temperatures being dealt with. The pipe wall or equivalent should also be well insulated for some distance from the thermometer well if this is not already the case and if the placing of such insulation will not materially affect the conditions of the test.

(*c*) The thermometer well should ordinarily be so constructed that it has the smallest possible metallic section consistent with the necessary strength just inside the wall of the pipe. This will tend to reduce the quantity of heat which can flow along the well with a given temperature difference, and, conversely, will tend to maintain the maximum possible difference of temperature between opposite ends of the well.

(*d*) The part of the well exposed to the medium whose temperature is to be determined must have the necessary surface to permit it to absorb heat as fast as it is lost from the exposed end (or to dissipate heat as fast as it is absorbed at the exposed end) without necessitating a temperature head in excess of that consistent with the degree of accuracy being sought.

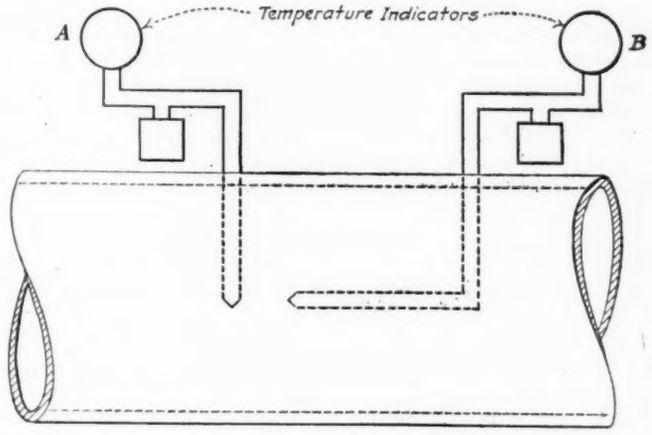


FIG. 3 METHOD OF INSTALLING THERMOCOUPLE TO AVOID EFFECT OF SURROUNDINGS

17 When it is necessary to use thermometer wells in measuring the temperature of a fluid within a conduit or vessel, the types to be used are as follows:

Fluid	Type of well
Liquid	Plain well (Fig. 1)
Saturated Vapor	Plain well (Fig. 1)
Gas	Finned well (Fig. 2)
Superheated Vapor	Finned well (Fig. 2)

The fins on the wells used with gas and superheated vapor compensate more or less for the lower rate of heat transfer from the gas to the bulb within the well as compared with the rate of heat transfer from a liquid to the bulb within the well.

18 Standard dimensions for thermometer wells are given in the section on Glass Thermometers.

19 Thermometer wells often are filled with liquids, such as lubricating oil or cylinder oil, and they are even packed with solids, such as graphite. When the temperature is low, so that oil does not vaporize, and when the temperature being measured is so nearly constant that the time lag resulting from its comparatively low thermal conductivity is not significant, oil may be used. Solid material should never be used if any liquid is available. The most satisfactory filling materials to be used in iron wells are as follows:

Temperature Range, Deg. Fahr.	Material
Up to 500	Mercury
500 to 1000	Solder
600 to 1800	Tin

20 When bare (unprotected) thermocouples or resistance thermometers or other forms in which the sensitive element is connected to an indicator of some sort by metallic wires or tubes are immersed in material having a temperature greatly different from that of the region through which the metallic connector runs on its way to the indicator, conduction of heat along such metallic parts should be minimized by running them for a sufficient distance through an isothermal zone. Imagine, for example, that gas is flowing through a flue of circular section as shown in Fig. 3 and that the temperature falls rapidly from the center toward the wall. If a couple is used to measure the temperature of the gas at the center of the flue and is installed so that the leads run radially outward as indicated at *A*, the temperature indicated will be lower than the real temperature for reasons already explained. If, however, the leads are run

along the center line of the flue for sufficient distance, as shown at *B*, the error will be reduced to a negligible amount. Attention is called to the fact that the same precautions are necessary with respect to any clamps or other fastening devices which are used to hold temperature-measuring devices in place. The instrument should be thermally insulated from the clamps and the latter should have such a shape that they do not conduct any appreciable quantity of heat away from the sensitive element and also that they do not cause a local drop in temperature of the medium in the neighborhood of the element. The same general precautions should be followed in measuring the temperature at any other point in the flue.

21 When it is necessary to place the sensitive part of a temperature-measuring device in a position where it can "see" surfaces at materially higher or lower temperatures than that of the medium in which it is immersed, the installation should be so planned as to minimize errors of the kind already described as arising from radiation under such conditions. When the material in which the device is immersed is flowing, this can be done by surrounding it with one or more shields of cylindrical section, so placed that the axes of the cylinders are in the line of flow. Such an arrangement is shown in Fig. 4. When there is no definite flow there is theoretically no means of protection against radiation error. However, if shields such as those described are used they will afford some protection if arranged in such a way as to prevent the sensitive element from "seeing" the hotter or colder surfaces, and if they are so arranged that the material in which they are immersed flows through them by virtue of the convection currents set up by local heating or cooling. Arrangements of this kind should be studied carefully as they may be so designed as to produce a larger error than the one they are intended to correct.

22 The size of the sensitive element is also of importance in cases such as that considered in the preceding paragraph. Radiation is a function of surface as well as temperatures. If the element could be reduced to a geometrical point having no surface there would be no error. Therefore the smaller the element under such conditions the better. It should be noted that dimensions here considered apply to leads or their equivalent, as well as the sensitive element itself. Thus a very small thermocouple with very large

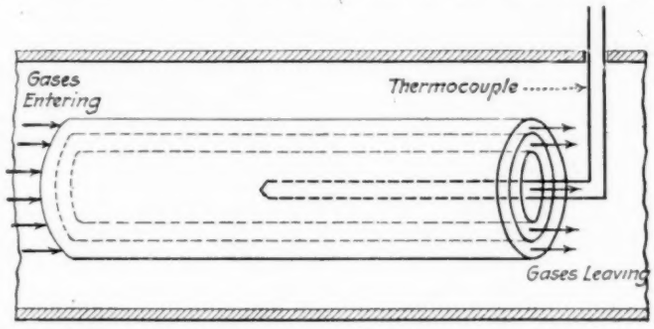


FIG. 4 METHOD OF USING PROTECTING SHIELDS FOR THERMOCOUPLE

leads might be very greatly affected by net radiation to or from those leads.

23 Protecting tubes as used with thermocouples are capable of producing errors of great magnitude if improperly used. Such tubes almost always have large external surface so that they exaggerate radiation errors. When made of metal they generally have large metallic cross-section and are therefore good thermal conductors, so that they cause errors of the type described in connection with thermometer wells. If a thermocouple is merely suspended in such a tube near the closed end its temperature must of necessity lag behind that of the tube wall, so that if rapid temperature variations are occurring the thermocouple is probably never very near to the temperature of the material being measured.

Correspondence

CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on activities or policies of the Society in Research and Standardization.

Compensation for Engineering Work

TO THE EDITOR:

The brief editorial entitled Compensation for Engineering Work, on page 867 of the October issue of MECHANICAL ENGINEERING, deserves further consideration and more thought by the engineering profession as a whole.

It would appear that in the reorganization of the Missouri, Kansas, and Texas Railroad the reorganization managers' and counselors' fee of $750,000 was exorbitant as compared to the engineers' fee of $156,675.

Engineers as a whole are creative and constructive, giving little thought to the commercial value of their services, whereas the banker's first thought is to make a profit and to keep up the standards of banking. Bankers know their value and demand a profit and compensation for services rendered. Corporate counselors and attorneys are retained as advisers and guides to help the bankers, industrial concerns, and the engineers to keep out of trouble and advise them as to the proper procedure for reorganization in order to legally and profitably formulate the best methods for safeguarding corporations and industries. Usually the counselors and attorneys get the first retainer, the bankers or underwriters the second, and lastly, if there is anything left, the engineers may get something. The bankers or underwriters must make a good profit to satisfy their stockholders and also to build up a surplus or reserve to enable them to finance tremendous industrial and railroad undertakings.

The environment of the average engineer, who has been educated and trained in an atmosphere of long hours, low wages, and low salaries, causes him to disregard the value of his services or of those who are in his employ. Take, for instance, the average educated draftsman and designer or engineer of 20 or 25 years' experience. His income is less than that of a plasterer, bricklayer, painter, or plumber, but the latter, through their unions and organizations, demand living wages and decent compensation. Some engineers will tackle an interesting problem without any thought of compensation, but as a rule the attorney's or counsel's first thought is, "What fee will I get out of the proposition?" Where a banker builds up a surplus in cash and an attorney builds up good stiff retainers and a substantial income, the engineer's surplus consists mostly of experience and the knowledge that goes along with the experience. Then, when most engineers reach executive positions, they have been raised in such a narrow environment of low wages, salaries, and fees that they give very little thought to helping those who are following in their footsteps. I know of several instances where executive engineers holding most important positions in this country do not have the nerve to present to their managements the thought of increasing the salaries of their low-paid assistants or putting them on a par with other professional men, and, rather than go out and employ specialists, they are trading around with manufacturers or their friends, endeavoring to get information and services free of charge.

I well recall one engineering problem that came up within the last few years where a very able and conscientious executive engineer called in the services of a consulting engineer, but the best he would pay this consulting engineer on a problem involving the spending of over $300,000 was one per cent to one and a half per cent for his services and the use of some valuable patents. Another executive engineer, rather than go to the management and ask for funds to assist in designing a plant, traded around among

manufacturers and then put a draftsman and a designer on the work, and when the plant was completed it was found to have cost an exorbitant sum. Had the specialist been employed, he would have saved them his consulting fee many times over.

Those who are associated with banking houses or underwriters think only in terms of gain, profit, or money at all times; in fact their whole thought in a transaction of any kind is the profit to be made, while the whole thought of the average engineer is to create a design, perfect that design, and then put it into successful operation—with the result that the majority of engineers do not think of merchandising or finance, their problems being entirely foreign to the subject of money or profit.

Engineers as a whole apparently neglect the commercial value of their services, and so many of them are living in such a narrow environment and concentrating on such interesting engineering problems that they forget they are not only depreciating their own worth but are committing a grave error and a mistake in not helping the profession as a whole. A very few engineering geniuses have been, and some are, well paid, but the great majority are underpaid.

COMMERCIAL ENGINEER.

Principles of Machine Design

TO THE EDITOR:

On page 955 of the November issue of MECHANICAL ENGINEERING occurs a very friendly review of my book The Principles of Machine Design. In a few particulars, however, the review contains statements which may have an important effect on eventual users of the book and yet carry an erroneous impression.

Thus there is a statement that no distinction is made between strength and stiffness. This matter is discussed for shafting quite fully on p. 592, and for crankshafts on pp. 286 and 287. It is true that in the case of crankshafts even the most scientific designers abstain from trying to figure deflections on account of the complexity of the case. Actually, however, the method of Güldner referred to on p. 286 is founded on a careful analysis of Ensslin's work on deformation. In automobile design the tendency is now to make both crankcases and crankshafts so stiff that no serious deformations can develop; but here even less than in other cases no computation of deflection is attempted. Those who have studied Ensslin's or Duffing's work on deformation will easily see why.

The reviewer also conveys the idea that the maximum-shear theory is dealt with only as a controversial matter in the introductory chapters. A detailed scrutiny of the book, will, however, show that throughout the book maximum-shear formulas are used for ductile materials in tension and shear, as well as for thick cylinders. This is done also for shafting whenever the stresses are actually computed. Practical formulas are used only when loads are uncertain—and this is very often true of line shafting; or where these formulas are founded on direct experiment (as, for instance, those of Bach for flat heads) and no better formulas exist. In the case of turbine disks, Stodola's theory is applied. This theory involves the figuring of the deformations at adjoining parts of the disks and is therefore in appearance a strain theory. The loading here is biaxial with two tensions, and in this case the maximum-strain theory is more defensible than is that of tension and shear, as witness tests at the University of Illinois, as well as those of Cook and Robertson. The Stodola method has been used universally in turbine design all over the world, with satisfactory results.

A few other criticisms are of somewhat minor importance. They flow from the fact that the actual publication of the book consumed no less than two years. In this time standardization progressed—for instance in the case of screws—to a point which the author could only hint at, and certain gear developments have taken place which likewise could not be adequately considered. An attempt was nevertheless made to bring all material up to date by brief references or notes. The erroneous impressions were of course created simply because it is hardly possible for a reviewer of standing to read in detail a book such as the one at issue.

C. A. NORMAN.[1]

Columbus, Ohio.

[1] Professor of Machine Design, The Ohio State University. Mem. A.S.M.E.

A System of Limits for Different Kinds of Fits

TO THE EDITOR:

The article on A System of Limits for Different Kinds of Fits, written by Prof. C. D. Albert of Cornell University, which appears in the November issue of MECHANICAL ENGINEERING, indicates that the author has given some study to the first report of the Sectional Committee on Plain Limit Gages for General Engineering Work entitled Allowances, Tolerances, and Gages for Metal Fits. However, he seems to disagree in a mild way with the Sectional Committee's definition and use of the word "allowance."

Regarding this, I would say that the Committee had many discussions on this term. It was found to have a broad, definite meaning in both this country and Great Britain among good engineers and designers. It is, in reality, a designer's term and represents the tightest fit he will allow and be responsible for proper functioning. The designer may neither know what variation in size can be maintained in the shop nor what the cost of doing it will be. He does, or should, know that a tighter fit may fail. If he has made a model, then all the fits represented in the model are the tightest fits allowable or, as sometimes denoted, "maximum metal."

The production is then quite usually taken up in the shop and the tolerances set, keeping in mind the cost of production and the looseness of fit permissible for the proper functioning of the article. Of course, there are some designers competent to do the whole thing but they are in the great minority. The Committee therefore had in mind the definition which already had a distinct meaning and gave model makers something to go by—that is, if class 3 fit is chosen by the designer, the figures representing the largest internal member and smallest external member, are to be used. The column headed "Tightest Fit—Allowance—" indicates the clearance of the fit in the model. When put into production, the tolerances, when used, make looser fits which are the only permissible ones.

The author touches on a much-argued question, the "hole or shaft basis," but does not give the fundamental which makes for either system, that is, "that there must be an undeviating point at which interference of metal takes place to maintain interchangeability." The Committee unanimously agreed that the best place for this zero or interference point was the standard or basic dimension. The general engineering world who have had opportunity to study the question agree to this. If now no other fits than moving ones were to be considered, the matter would be settled without any more ado about "shaft or hole basic."

However, as force fits are required, it means that either the dimensions of the whole members must cross the basic interference point or that of the shaft members. If the hole members cross it, the system is "shaft basic." If the shaft members cross it, the system is "hole basic." As either the smallest hole of the external member must be basic or the largest shaft of the internal member must be basic to maintain the Committee's idea of the "fundamental," the Committee unanimously agreed that the overwhelmingly greater part of production work would be benefited by keeping the minimum dimension of the external member basic. The committee also believed that the setting up of two systems as the Germans did, would be the worst thing they could do, for the reason that all of the work made to the one system would not interchange with all of that made to the other system.

Indeed, it would be nearly as bad as the conditions existing during the World War, and most of the Committee had more or less to do with the millions of parts that were required to fit and function and they knew the endless trouble that the lack of a definite system caused.

This Committee also knew how much time and money would have been saved if the present proposed standard could have been adopted by the Army and Navy.

It is my opinion that too much stress has already been put upon the arguments for "shaft or hole basic," and that the sooner it is forgotten, the better off the manufacturing public will be. The use of tolerances prevents any of the mating members from having basic dimensions anyway, unless the extreme limits are used and this would be bad practice, so why argue about something which rarely happens?

The author states, "Where the holes are so large that reamers would not be used. . . .the shaft is a better basis for a system than the hole," but he offers no proof to support it. My manufacturing experience covering 35 years does not support this statement. Job-shop and made-to-order material cannot follow any system, so that this kind of work should be eliminated from even discussion. Cold-rolled, turned, and ground shafting is, and always has been from basic to under basic, and very rarely, indeed, can any be found up to basic, so that all of it will go into holes that are from basic to over basic.

It is pointed out that often various fits are required on the same shaft and that the system proposed by the Committee does not admit this, which in a measure is true, but the Committee did not think that 80 per cent of the manufacturing public should be penalized for the 5 per cent who have sufficient of this work to feel it.

It is the Committee's present idea to first establish the proposed system and then later, when the resulting economy is apparent, to set up what probably will be termed "Special Cases." This will be advocated for transmission work, etc., where it will be found an advantage in "Special Cases" to vary the hole member. The Committee, however, does not propose, at present, to offer the public a choice of two system for manufacturing fitted parts that may prevent interchangeability as the Germans have done.

E. C. PECK,[1] *Chairman.*

Engineering and Industrial Standardization

Safety Code for Aeronautics[1]

THE Safety Code for Aeronautics has been completed and submitted to the A.E.S.C. by the sponsors, the Bureau of Standards and the Society of Automotive Engineers, for approval as a tentative American standard. The code is divided into ten parts, taking up the following: Airplane Structure—Design, Fabrication and Tests; Power Plants—Design, Assembly and Tests; Equipment, Maintenance, and Operation of Airplanes; Signals and Signaling Equipment; Airdromes and Airways; Traffic and Pilotage Rules; Qualifications for Airmen; Balloons (Free and Captive); Airships; Parachutes.

It is fully appreciated by the Sectional Committee formulating the code that aeronautics is in its infancy, that the art is rapidly developing, and that the time has not arrived for that degree of standardization which means crystallization into set forms of structures or of practices. It is not intended, therefore, that this code should prevent development by prescribing too closely the acceptable methods of design, construction, or operation. The intent has been rather to formulate canons of good practice which should be helpful in utilizing the experience of the past by indicating proper practice and eliminating that which has already been found unnecessarily hazardous.

Safety Code for Paper and Pulp Mills

THE National Safety Council as sponsor has recently submitted the Safety Code for Paper and Pulp Mills to the American Engineering Standards Committee for approval as a tentative American standard. The Sectional Committee consisting of 17 members representing 15 societies and associations has voted unanimously in favor of the present draft.

The history of this code extends over a long period of time. The paper and pulp mills safety code was a part of a program for securing safety codes on a variety of subjects for a variety of industries. At the time of the formation of the Safety Codes Correlating Committee, this program for safety codes was presented and approved by the then Safety Codes Correlating Committee. Mr. S. J. Williams then Vice-Chairman of the Safety Codes Correlating Committee, accepted on behalf of the National Safety Council the sponsorship of the paper and pulp mills safety code among others. At that time the Paper and Pulp Section of the National Safety Council had a committee working on the development of safe practices pamphlets on paper- and pulp-mill hazards. One of these pamphlets had been completed and others were under way when this same committee was requested to turn their attention to the paper and pulp mills safety code. This committee consented to do this with the assistance of representatives from other bodies.

The first work was started on the code some time near the end of the year 1920. Several preliminary meetings were held during the year 1921, and the first draft of the code was prepared for discussion August 15, 1922. Members of the committee and representatives of paper mills in the membership of the National Safety Council had manifested great interest in this code. There is a demand for this code, especially on the part of the management of companies operating mills in different states of the United States and provinces of Canada. The Sectional Committee for the code was formed by the National Safety Council.

Members of the Paper and Pulp Section of the National Safety Council, representing about 125 paper mills of all kinds, were asked to comment on the various drafts of the code. Considerable assistance was received in this way. At the annual congresses of the National Safety Council held in Buffalo, New York, in 1923 and in Louisville, Kentucky, in 1924, the paper and pulp mills safety code was discussed by the members in attendance. In addition, members of the Sectional Committee met in three different paper-mill centers with representatives of mills and discussed the provisions of the code that applied to the operations in those particular centers. The greatest amount of help that the Committee has received was at the special meetings and at the meetings of the Paper and Pulp Section of the National Safety Council at its annual congresses.

Bolt, Nut, and Rivet Proportions

A CONSIDERABLE amount of progress has been made recently by the six sub-committees forming the Sectional Committee on the standardization of Bolt, Nut, and Rivet Proportions. A brief summary of the present status of the reports of these committees is given below.

Large and Small Rivets. The standard for Tinners', Coopers', and Belt Rivets, and the standard for Small Rivets are in galley-proof form. A tentative draft of the standard for steel rivets $\frac{1}{2}$ inch in diameter and larger is to be reviewed and discussed at a meeting of this Sub-Committee scheduled for Annual Meeting week.

Wrench-Head Bolts and Nuts. The revised draft of the Sub-Committee's report in page-proof form was thoroughly discussed at a meeting of Sub-Committee No. 2 in Milwaukee, Wis., on May 20. The final revision of the proposed standard by the Sub-Committee is to be reviewed at a meeting of the Sectional Committee on December 2. Prior to this meeting the report will be informally considered by the Bolt, Nut, and Rivet Manufacturers' Association, and copies are to be mailed to the technical press and interested firms and individuals.

Slotted-Head Products. The Sub-Committee is at work revising the part of its report having to do with the screw and thread lengths. Agreement on the head proportions of all types of slotted heads has been reached in the Sub-Committee, so the complete report will soon be placed before the members of the Sectional Committee.

Track Bolts and Nuts. The part of the tentative report of Sub-Committee No. 4 dealing with head dimensions has been informally considered by the railway interests through the representatives of

[1] Statement taken from A.E.S.C. Sustaining Members' Bulletin of October 16, 1925.

[1] Chairman, Sectional Committee on the Standardization of Plain Limit Gages for General Engineering Work.

the American Railway Association on the Sectional Committee, and it is understood that this part is acceptable to them.

The Sub-Committee is now just completing a series of tests on the tolerances for the screw threads of these bolts. An attempt is being made to adopt a combination of the tolerances established by the American (National) Screw Thread Standard for the threads on these bolts. It is recognized, however, that such a special combination of tolerances is necessary to meet the exacting service demanded of track bolts.

Round Unslotted Heads. The head dimensions of the Regular Carriage Bolt, Fin-Neck Carriage Bolt, Ribbed Carriage Bolt, Step Bolt, Button-Head Machine Bolt, and Countersunk Carriage Bolt included in the present report are generally agreed to by members of Sub-Committee No. 5 and the Sectional Committee. The Sub-Committee is now at work on body and minimum thread lengths for these six types of bolts.

Plow Bolts. As recorded in the February, 1925, issue of MECHANICAL ENGINEERING, the revised report of Sub-Committee No. 6 was submitted to letter ballot of the Sectional Committee during the summer. Though not entirely complete, this ballot indicates approval by the representatives of the twenty societies and associations officially coöperating in this project. When the result of the ballot is formally transmitted to the S.A.E. and the A.S.M.E., the sponsors for this project, they in turn will transmit it after action by their Boards, to the A.E.S.C. for final acceptance as a tentative American standard.

The screw threads of all the above-mentioned bolts, screws, and nuts are to be specified as the American (National) Standard (See A.E.S.C. No. Bla-1924).[1] Some of the various types of bolts and screws will have their threads rolled, formed, or cut to conform to the American (National) Standard Coarse-Thread Series, and others to the American (National) Standard Fine-Thread Series. The classes of fit specified in the screw-thread report will also be recognized. For instance, the thread designated in the plow-bolt standard is Coarse-Thread Series—Free Fit (Class 2).

Standardization of Screw Threads in U. S. Moves Forward

A BIG ADVANCE toward the universal adoption in the United States of the American (National) Standard Screw Thread was made recently when the leading manufacturers of die heads and thread chasers held two conferences in the room of The American Society of Mechanical Engineers. The purpose of these conferences was to discuss methods by which the users of screw threads could be encouraged to adopt in their plants the American Standard Screw Thread.

It will be recalled that this American Standard was approved by the American Engineering Standards Committee in May, 1924, having been transmitted to it by the Society of Automotive Engineers and The American Society of Mechanical Engineers as joint sponsors for the Sectional Committee on the Standardization and Unification of Screw Threads. This Sectional Committee began its work in the spring of 1921 following the publication of the Progress Report of the National Screw Thread Commission, Miscellaneous Publication of the Bureau of Standards No. 42. The Sectional Committee carried through its work in close cooperation with the N.S.T.C., and the report dated April, 1924, had the full agreement of the Commission. The report of the N.S.T.C. published in February, 1925, as Miscellaneous Publications No. 61, includes the material comprising this standard in a slightly different form.

The die-head and chaser manufacturers have agreed to stock chasers for a large percentage of the thread sizes and pitches included in both the Coarse-Thread Series and the Fine-Thread Series for screws and bolts as well as the American Standard Straight and Taper Pipe Thread. They have, of course, also planned to stock chasers for certain other threads which, though not now American Standards, have become well established in the industry. Some of these are used by the workers in steel plate, by the manufacturers employing thin brass tubing in the production of luminaires and thin metal ornaments, by the makers of spark plugs, etc.

These conferences were highly successful, for, when the stock lists of the different makers were examined, it was found that the variety and sizes of screw-thread chasers could undoubtedly be reduced from the more than 2000 now stocked to less than 200. This program will be of great advantage to industry and will at the same time enable the die-head manufacturers to give far better service to the users of screw threads by helping to wipe out the complications now existing. It should be recalled here that the manufacturers of machine screws have held similar conferences and, using the standard set up by the above-mentioned Sectional Committee as the basis for their action, have agreed on a list of machine screws of the various diameters, pitches, and lengths which should be carried in stock. These lists have since been published for the information and convenience of the users.

Representatives of the Sectional Committee on the Standardization and Unification of Screw Threads, the National Screw Thread Commission, and the Department of Commerce, Division of Simplified Practice, were present and were enthusiastic over the results obtained by these two conferences. At a later date the Division of Simplified Practice will probably hold a general conference in Washington to consider and pass on the stock lists prepared by the die-head manufacturers.

Safety Proposal for Rubber Machinery

A TENTATIVE draft of a safety code on mills and calenders,[1] to be part of the Safety Code for Rubber Machinery, has been worked out by the sub-committee appointed for this purpose.

Emergency stopping distances have been agreed upon by the chairmen of the sub-committees, and the draft has been sent out to elicit suggestions or criticisms which it is planned to consider in an open meeting of the code committee. (E. W. Beck, Secretary, 1790 Broadway, New York City.)

It is realized that the possibility of the quick stopping of mills and calenders is a very important factor in accident prevention, in that it limits the injury to a worker if he is caught between the rolls. At the present time, due to the different type of drives and controls for stopping, there is a wide variation in the distance that a roll will travel after the safety trip has been operated.

Some form of braking device is absolutely necessary. With stock in the mill or calender the stop is much quicker than when the mill or calender is running empty, but in order to have a standard condition for testing and comparison it is necessary to make tests for quick stopping with all the equipment running idle.

A great many tests have been made to determine the distance a roll will travel after the safety control is operated, and rules given in the draft show what may reasonably be expected with average good conditions, and with as quick a stop as can be obtained without seriously jarring the machinery or breaking the equipment.

SPECIFICATION NO. 230, 1925, which has just been published by the British Engineering Standards Association, covers the requirements for portable photometers intended for the measurement of illumination, and in some cases of brightness also, under conditions where portability and convenience in use are of more importance than great accuracy. The specification includes definitions of the principal terms used in photometry, which terms are in accordance with the decisions of the International Illumination Commission, in so far as such decisions are applicable. It divides the photometers into two ranges, Range A being those photometers intended for use in measuring exterior illumination, and Range B being those intended for use in measuring interior illumination, and it points out that as usually constructed portable photometers of each range may be further subdivided into those in which the test surface is viewed through an aperture in the comparison surface and those in which the comparison surface is viewed through an aperture in the test surface. *The Engineer*, Oct. 30, 1925, p. 462.

[1] This report, in the form published by The American Society of Mechanical Engineers, may be obtained by addressing the Society at 29 West 39th Street, New York, N. Y. Price 50 cents.

[1] Statement taken from A.E.S.C. Sustaining Members' Bulletin of October 16, 1925.

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St. New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society, for approval, after which it is issued to the inquirer and simultaneously published in MECHANICAL ENGINEERING.

Below are given interpretations of the Committee in Cases Nos. 481 (Reopened), 486 (Reopened), 493, 497 (Reopened), 499, 500 to 511, inclusive, as formulated at the meeting of September 18, 1925, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE NO. 481 (Reopened)

Inquiry: In calculating the strength of the rivets in shear in reinforcements for openings larger than 3 in. pipe size, under Par. P-261 of the Code is it necessary to figure one-half of all the rivets in the reinforcement, or should the first two rivets on the horizontal center line be deducted and then one-half of the balance figured?

Reply: It is the opinion of the Committee that the application of Par. P-261 to such a reinforcement as described will necessitate that the first two rivets on the horizontal center line must be deducted and that one-half of the remaining rivets shall be used for the calculation of the strength of rivets in shear. Attention is called by the Boiler Code Committee to the fact that the rule in Par. P-261 may give illogical results, and that it is the opinion that it should be applied only to the reinforcement of manhole openings. The Committee announces that a sub-committee is at work on a logical rule for any reinforced opening, which will be submitted later on.

CASE NO. 486 (Reopened)

Inquiry: Is it permissible, under the requirements of either Par. P-295 or P-321, to so arrange the water connection between a boiler and a water column that there may be a pocket in the pipe which may cause the lodgment of sediment, even though a cross is provided to facilitate cleaning?

Reply: The Committee recommends that where there are water connections between a water column and a boiler having a rising bend or pocket which cannot be drained by means of the water-column drain, an additional drain be placed on the connection in order that it may be blown off to clear any sediment from the pipe.

CASE NO. 493

Inquiry: Under the revised requirement in the Low-Pressure Heating-Boiler Code for calculation of minimum allowable sizes of safety valves on the basis of the grate area of the boilers, what part of the total grate area of a down-draft boiler is to be considered equivalent to the total grate area of a direct-draft boiler?

Reply: It is the opinion of the Committee that in applying the revised rule in Tables H-6, H-7, H-10 and H-11 of the Code, the effective grate area in down-draft boilers shall be taken as the area of the upper grate plus one-eighth of the area of the lower grate.

CASE NO. 497 (Reopened)

Inquiry: Is it not the intent of the marking requirements in Par. U-66 of the Code that it shall be optional for the manufacturer to stamp directly on the shell plate, or solder a name plate to the shell plate, as is provided for in Par. P-332 of the Power Boiler Section? With tanks having thin shells it is very difficult to apply the marking by stamping.

Reply: It has been the intent of the Committee to provide for the marking of unfired pressure vessels along such lines as will conform in general to the corresponding requirement in the Power Boiler Section of the Code, and it is the opinion of the Committee that to mark pressure vessels by use of a name plate, brazed, or otherwise irremovably attached to the shell plate, will conform to the spirit of the requirement in Par. U-66.

CASE NO. 499

(In the hands of the Committee)

CASE NO. 500

Inquiry: When it is known at the time of manufacture that a water screen is to be supplied with the boiler, should the shop inspector add the water heating surface contained in the water screen to that of the boiler proper to obtain the correct amount to be stamped on the boiler as representing heating surface, or should the heating surface of the boiler alone be stamped on it, leaving to the field inspector the duty of adding the screen surface to the boiler surface in estimating the required minimum sizes of safety-valves?

Reply: In stamping a boiler at the time of manufacture, in compliance with item 5 of Par. P-332, it is the opinion of the Committee that only the water heating surface of the boiler proper should be included. When additional steam-generating surface is connected to the boiler circulation, the safety-valve capacity must correspond to the maximum evaporation of the combined surface as called for in Par. P-270.

CASE NO. 501

Inquiry: In the case of steel-plate, hot-water heating boilers, which, under the requirement of Par. H-1 of the Code, exceed 60 in. in diameter, and thus are required to be constructed in accordance with the Rules for Power Boilers, is it the intent of the Code that the Power Boiler Rules shall apply only so far as constructional details and settings are concerned, or are the requirements for fittings and attachments, including safety valves, water and steam gages, etc., in the Power Boiler Rules also applicable? It is pointed out that the Power Boiler Section of the Code contains no provision for water-relief valves.

Reply: It is the opinion of the Committee that it was the intent of Par. H-1 that steel-plate, hot-water heating boilers that exceed the limits specified in item *b* should be built in accordance with the requirements in the Power Boiler Section for constructional details and setting only, and that the requirements in that section for fittings and attachments are not applicable to heating-boiler conditions. For the latter, the requirements in the Low-Pressure Heating-Boiler Section of the Code pertaining to fittings and appliances are considered applicable.

CASE NO. 502

Inquiry: The minimum size of pipe connecting water columns to boilers is definitely specified in the Power Boiler Section of the Code, but no corresponding requirement appears in the rules when the glass is connected directly to the shell or drum, and not to a water column. Is it not the intent of the Committee that pipe connections for the gage-glass mountings connected directly to the shell or drum be of such a size ($\frac{1}{2}$ or $\frac{3}{4}$ in.), as will insure reliable water-level indications?

Reply: The Committee would recommend that the pipe sizes for the conditions outlined be not less than $\frac{1}{2}$ in.

CASE NO. 503

Inquiry: Par. P-212*c* of the Code permits a much greater allowance for longitudinal than circumferential pitch between staybolts in furnaces of vertical fire-tube boilers 38 in. or less in diameter, but apparently no allowance is made in the staying for the increase of strength of the furnace sheet due to its convex shape, and unduly large staybolts are required. Will it not be permissible to take the square of the circumferential pitch and ignore the longitudinal

pitch in order to determine the load for which the staybolt shall be calculated?

Reply: The Code makes no provision for such reduction of loading on staybolts for reason of increase of strength of the convexed furnace sheet over that of a flat sheet. The loading on the staybolts must be calculated as specified in Par. P-212*d*.

CASE NO. 504

Inquiry: In line 3 of the Manufacturers' Data Report for miniature boilers, both a manufacturers' serial number and an A.S.M.E. number are called for, while the similar item in the Manufacturers' Data Report form in the 1924 Edition of the Power Boiler Code indicates that the A.S.M.E. serial number may be the manufacturers' serial number, at the manufacturers' option. If such practice is permissible for power boilers, is it not the intent of the Committee that it should also be permitted for miniature boilers?

Reply: Line 3 of the Manufacturers' Data Report for miniature boilers conforms to the similar requirement in the Manufacturers' Data Report form in the 1918 Edition of the Code. It is the opinion of the Committee that as a result of the revision in this item as above referred to, it should be optional for the manufacturer working under the Miniature Boiler Code to use either separate series for these numbers, or to combine them as provided in the 1924 Edition of the Code, as may be desired.

CASE NO. 505

Inquiry: Is it not the intent of exemption (*c*) that precedes Par. U-1 of the Code that the so-called pneumatic tanks used in connection with water pumps for private residences and farm-building water supplies should be construed as vessels containing water for domestic supply?

Reply: It is the opinion of the Committee that where water pressure vessels of the type referred to, in which the compression of air serves only as a cushion in a water-supply system, or in air-lift-system tanks containing mixed air and water, the exemption (*c*) in the Code for Unfired Pressure Vessels is applicable.

CASE NO. 506

Inquiry: Is it the intent of the third item in the classification of miniature boilers pertaining to total heating surface, that this limitation shall apply to the total heating surface including the superheating surface of tubes above the water level in vertical tubular boilers, or does it apply merely to the water-heating surface of such boilers?

Reply: A literal interpretation of this limitation would indicate that it covers both water-heating and superheating surface in miniature boilers of the type referred to. It is the opinion of the Committee, however, that this limitation should apply solely to water-heating surface.

CASE NO. 507

Inquiry: Is it permissible in mounting a boiler bushing through a $^{9}/_{8}$-in. head of an h.r.t. boiler, to use a bushing with a long threaded stem which can be inserted through a hole in the head and fitted with a lock nut on the inner side, instead of riveting on a flange or plate as specified in Par. P-268 or otherwise reinforcing the head to afford the required number of threads in the head?

Reply: It is the opinion of the Committee that if a boiler bushing of such construction be inserted through a head or shell as above described, and the lock nut used has the full number of threads specified in Par. P-268 for the particular thickness of head or shell, the construction may be considered to meet the requirements of Par. P-315.

CASE NO. 508

Inquiry: If safety valves, blow-off valves, and other boiler fittings are of cast-steel construction, what specifications must the steel conform to, to meet the requirements of the Code?

Reply: There is no requirement in the Code at present pertaining to material requirements for bodies of safety valves, blow-off valves, etc. Attention is called, however, to the last paragraph on page *e* of the Preamble of the Code, which points to the addition of such rules and specifications for pipe fittings, etc., as soon as completed by another Committee of the Society.

CASE NO. 509

Inquiry: (*a*) Is it the intent of Par. M-2 of the Code to ignore the specifications as given in Section II of the 1924 Edition of the Code, for seamless or extra-heavy lap-welded steel or iron pipe or tubing for use in miniature boiler shells, provided, however, it is of open-hearth material and is formed by the forging process?

(*b*) If this is the intent of the Miniature Code, what is the minimum wall thickness allowable?

Reply: (*a*) When the Code for Miniature Boilers was formulated, there were no specifications available to which such steel or iron pipe or tubing could be referred to in the Code. Since the 1924 Edition of the Code has been issued, however, there are such specifications in Section II thereof and it is the opinion of the Committee that these specifications are applicable for the material as referred to in Par. M-2 of the Code for the shells or drums of miniature boilers. It is proposed to revise the Code for Miniature Boilers to incorporate references to these specifications.

(*b*) Under Par. M-3 the minimum thickness of the shells above referred to will be $^{1}/_{4}$ in. when riveted construction is used, or $^{3}/_{16}$ in. when seamless construction is utilized.

CASE NO. 510

Inquiry: Is it permissible, under the Low-Pressure Heating-Boiler Section of the Code, to rivet cast-iron flanged nozzles to the shells of boilers where the working pressure does not exceed 15 lb.?

Reply: There is nothing in the Heating-Boiler Section of the Code that provides for the construction of boiler nozzles or their attachment to boiler shells. It is the opinion of the Committee that properly designed flanged nozzles of cast-iron construction, when attached to boiler shells by riveting, will constitute safe construction.

CASE NO. 511

Inquiry: Is it the intent of Par. P-277 that only a standard fitting may be placed between the safety valve and the boiler drum outlet, or can it be interpreted that this requirement will permit a fitting in accordance with the Tentative American Standard for Steel Pipe Flanges and Flange Fittings to be used?

Reply: It is the opinion of the Committee that if the face-to-face dimension or length of the fittings is in accordance with the Tentative American Standard that is now under preparation by another committee of the Society, and of which the Proposed Standards have been published, the requirements of Par. P-277 may be considered as complied with.

A Sixth Great Lake

AN ELABORATE scheme for the creation of a "sixth great lake," twice the size of Lake Ontario, in northern Ontario, was placed before the associated boards of trade and chambers of commerce of Ontario at Kingston, Ont., on November 5.

The proposal, as outlined by C. Lorne Campbell of Toronto, means the building of two dams across the Albany and Ogoki Rivers to turn the waters of these streams away from the James and Hudson Bays into Lake Nipigon. This, according to Mr. Campbell, would create a lake 200 miles long by 90 miles wide and cause to be submerged an area of 18,000 square miles.

The cost is estimated at $200,000,000 and 20,000 men would be employed for six years. The expenditure would not fall on the shoulders of the province of Ontario, according to Campbell, except in the way of agreeing to take a certain horsepower of the vast new electrical energy developed at three centers. The capacity at Cameron Falls would be increased by 175,000 or 200,000 hp.; the power plant at Sault Ste. Marie would have its capacity increased by 40,000 or 50,000 hp.; at Niagara Falls 300,000 hp. would be added. In all an increase of 500,000 hp.

The scheme, international in scope, in Mr. Campbell's opinion, would overcome the Chicago diversion of water from the great lakes in twelve or fourteen years, at the end of which time the level of the lakes would be back to normal. *Power*, Nov. 17, 1925, p. 783.

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers and Proceedings of

The American Society of Mechanical Engineers

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Engineering Aspects of the Air Mail

THE Air Mail maintains a flying schedule of nine hours and fifteen minutes on the westbound trip from New York to Chicago, and letters mailed at nine in the evening in New York are delivered by the first carrier delivery next morning in Chicago. Between New York and San Francisco the flying time is only 34 hours and 20 minutes, and letters are delivered between the two cities in less than forty-eight hours. The last fiscal year 9,300,520 first-class letters were carried, the number increasing every month. When the various feeder lines such as Boston to New York, Salt Lake City to Los Angeles, and others for which contracts are being placed come into operation, the effect on the nation's business life will be still greater. This great improvement in mail transmission—the most important since the adoption of the railway postal system in the sixties—concerns bankers, business men, manufacturers, and engineers alike. Perhaps it interests engineers more than men in other walks of life, because of its many technical aspects.

The Air Mail system, first of all, is having a most encouraging effect on the design of commercial airplanes. The rebuilt DH-4's of war fame with which the Air Mail is still operating carry a pay load of only 500 lb. with a speed of 120 miles per hour, and burn at least 25 gal. of fuel per hour in cruising with their huge Liberty motors. For the new feeder lines American engineers have developed planes around the new air-cooled engines which carry the same amount of mail at the same speed and for the same range with motors of only 200 hp. capacity. Since the market for commercial airplanes is so restricted, the Air Mail may be said to be the driving force behind the development of commercial planes.

The system may also be regarded as a vast experiment in the commercial reliability of aircraft. In a statement before the President's Air Board the Postmaster General points out with pride that for the fiscal year ending in June, 1925, the service flew 2,076,764 miles out of the 2,160,022 miles scheduled, or 96 per cent of them, in all manner of weather and across much difficult country. The Air Mail, not waiting for engineers to develop the perfect plane, is teaching the world that reliability of operation is possible with the material even now at hand.

The outstanding engineering feat, however, is probably the establishment of night flying over the first illuminated airway in the world. The night airway, installed at an outlay of $514,405, now extends over 1866 miles between New York and San Francisco and is maintained at an annual cost of $295,212. Huge electric lights of 500,000,000 candlepower guide the pilot at intervals of 25 miles or more. Flood lights of almost equal power are used at every regular field and give the pilot a daylight perspective on landing, with rays so regulated as to avoid all blinding glare. Smaller gas routing beacons at three-mile intervals and the lighting of all emergency fields complete a wonderful system. The lighting of the planes themselves has been developed just as carefully. Running or navigation lights, landing lights on either wing tip of 150,000 candlepower, cockpit instruments painted with luminous paint, and emergency parachute flares have all been employed to give safety at night equal to that of day flying.

The Air Mail is also arousing the ingenuity of inventors and designers in the production of radio direction finders and in such interesting devices as electrical height indicators, warning the pilot of the too great proximity to earth in fog or darkness.

Certainly the engineer may regard these achievements with pride since they are so largely engineers' work.

And while it is to be hoped that the carrying of mails by air will soon pass entirely into private hands, too much credit cannot be given to the Post Office Department for a difficult, patient effort which has benefited not only aviation but the entire economic life of the country.

A.S.M.E. Pledges Coöperation to New War Secretaries

THE voice of America is for peace and justice among nations. In order to be just, however, it is not necessary or even possible that we should be weak. The World War taught us the value of preparedness. Whenever our national program is so arranged that the resources of this country may be made available promptly in case of emergency, our voice will be the most potent in the peace councils of the world. Therefore the work of Industrial Preparedness is not an effort to promote war, but our greatest possible contribution for the maintenance of peace.

There could be no greater cause for congratulation and thankfulness on the part of peace lovers than that our Secretary of War should be at once a man who has been a warrior but who believes in peace, and who recognizes fully and intelligently what Industrial Preparedness means in its deepest sense for national and international welfare. By his appointment of Col. Dwight F. Davis to be Secretary of War, President Coolidge has not only recognized the fine work which Colonel Davis has already accomplished under the provisions of the National Defense Act, but has furnished even a wider opportunity for a continuation and extension of these policies.

To the Secretary of War, and to the new Assistant Secretary of War, Colonel MacNider, under whose immediate direction the program of Industrial Preparedness will now be developed, The American Society of Mechanical Engineers pledges the best cooperation of which it is capable. Clear thinking and definite planning in advance of action are processes with which it is easy for engineers to find themselves in thorough accord.

FRANK A. SCOTT,
Chairman A.S.M.E. National Defense Division

Progress in Mechanical Engineering

THE twenty-six pages of reports of progress in the many branches of mechanical engineering which appear in this issue are a welcome addition to engineering literature.

This collection of statements from the A.S.M.E. Professional Divisions forms an important document which will be of great value as the basis for future meeting programs, for research projects, and for various standardization activities. If the Society is to cover its field thoroughly, a yearly survey of this kind is necessary, for in the rapidly advancing science and art of mechanical engineering, the new problems must be searched out and the changing nature of the old ones generally understood if the Society is to provide the great clearing house of new thought and develop-

ment that its members need. In the Society's campaign to advance engineering knowledge, the presentation and public discussion of these reports serve to define the frontier zone of the unknown against which research attacks may be launched, or in which the skirmishes of public discussion may take place. Gained knowledge may be consolidated by standardization or by codification. As Dr. Durand concisely says in his Foreword to these reports, "If progress is to be made, problems must be studied, and in order to be studied, they must first be recognized."

But these progress reports fulfil another important function. They present a picture of the trend of the entire profession, and as such furnish interesting and stimulating reading to the busy specialist. In the ever-widening path of science and engineering, advances in our field that are of value to another may be lost. These statements of progress in many phases of mechanical engineering should therefore be of invaluable assistance to engineers who wish to keep abreast of their profession.

The Professional Divisions are to be heartily congratulated for this collection of statements in regard to progress and prospects in mechanical engineering. They are as complete as is possible in the first presentation. The technic of collecting progress statements will be improved as the Divisions profit by their experience in this their first effort, and it is possible to foresee the time when the presentation and discussion of the year's reports will furnish the major part of the program for a Society meeting.

Engineers in Public Service

THE need for properly qualified technical men in public service is emphasized in the following resolution adopted by American Engineering Council in May of this year:

WHEREAS, It has frequently come to the attention of American Engineering Council that public positions and offices requiring engineering or technical training, skill and experience are often filled with persons wholly lacking in such qualifications; and

WHEREAS, Such practice is inimical to and not in the interest of public policy and well being, the protection of life, health and property; therefore, be it

Resolved, That American Engineering Council urgently recommends that public positions and offices requiring engineering or technical training, skill and experience be filled only with technically qualified persons; and be it further

Resolved, That all State and Local Engineering and Technical Societies be urged by American Engineering Council to coöperate with the public to obtain such proper officers.

This resolution was not prompted by the thought that technical positions in public service, as a general rule, are held by incapable men. It is to be borne in mind that the inducements offered by such employment, especially in the more responsible positions, are often unattractive. The assured tenure of office is comparatively brief, compensation is rarely adequate to attract men of the highest type, and finally, politics is often permitted to interfere with the best interests of the work in hand. In view of these conditions it is rather surprising to find responsible engineering positions in many cases filled with capable and conscientious men.

It must be admitted, however, that there are instances where such is not the case. It was with the thought of aiding in the correction of such instances that the resolution given above was adopted.

As a rule, those responsible for the administration of municipal, state, or federal government are anxious to serve the people as best they can. While the appointment of inferior men is often due to political exigencies, it is probably more often due to a lack of knowledge of the importance of the issues involved. This is particularly true of technical positions. Few people realize that the radical changes in our mode of living which have come about during the past twenty years have resulted in new problems, the solution of which requires, to an ever-increasing extent, the trained mind of the engineer. Many questions dealing with the public service involve engineering to a very large extent, and in some cases the problems to be solved are altogether of an engineering nature. Unless those who are charged with the responsibility of filling technical positions are acquainted with these facts, they cannot make wise decisions.

In view of the above, the engineer has a civic duty to perform in acquainting the public at large with the importance of the proper solution of engineering problems. A realization of this truth will tend to result in the appointment of capable men.

Engineers as a class are, perhaps, inclined to live to themselves to a greater extent than other professional men. When some particular emergency arises they may, it is true, take some specific action, but under such conditions their motives are apt to be misconstrued. The engineer should endeavor, as a continuing policy, to make his influence felt in the community by taking a more active part in civic affairs. He should make his opinion known on engineering matters of civic interest. He should be willing and anxious to speak before various civic bodies, particularly as such bodies represent, as a rule, those citizens who are more or less active in public matters. He should endeavor, through informal meetings of one sort or another, to properly inform the officers of the public service on engineering problems, standing ever ready to assist in any way he can. He should make it plain that his efforts are inspired by a sense of civic duty, and not with any thought of direct personal gain.

The local engineering organization can be of great value in this connection. All engineers of a particular community, regardless of the branch of the profession to which they belong, should be united in some form of organization which can speak authoritatively on engineering matters of common interest. Absolute agreement among engineers on any particular problem is necessary if public confidence is to be inspired.

Certain St. Louis engineers recently gave two informal dinners, to one of which members of the Board of Aldermen were invited and to the other the St. Louis members of the State Legislature. The attendance at these meetings was very gratifying. No specific legislation was urged or even suggested. No engineer present had an "ax to grind." The purpose of these informal meetings was to acquaint the guests with the importance of correct solutions of engineering problems in general, and furthermore, to tender the good offices of the engineers as a body for such use as the legislators might see fit to make of them. I might mention other instances where a similar plan was followed with marked success.

If the engineer is not satisfied with the manner in which technical positions in public service are being filled, he should bear in mind that this condition is often due to a lack of understanding of the problems involved, and it should, therefore, be his first duty to attempt to correct this situation.

W. E. BRYAN.[1]

Engineering and Science

IF WE consider the engineer as the man who applies the results of the work of the pure scientist for the economic and social well-being of mankind, it will be quite obvious that intimate relations between scientists and engineers are a fundamental necessity. To provide one contact The American Society of Mechanical Engineers has established the Robert Henry Thurston Lectures, the first of which is to be presented at the 1925 Annual Meeting. Engineers, however, have a contact with science which has not been generally understood and appreciated by engineers, and that is the Engineering Section of The American Association for the Advancement of Science. This Engineering Section includes the major engineering societies of the country, and it holds a meeting at the time of the annual meeting of the A.A.A.S.

It so happens that the president of the A.A.A.S. is Dr. M. I. Pupin, an engineer as well as a scientist and president of the American Institute of Electrical Engineers. Dr. Pupin is keenly desirous of more intimate contact between engineers and scientists, and as his feeling is heartily seconded by Dr. Charles Russ Richards, president of Lehigh University and chairman of the Engineering Section of the A.A.A.S., engineers may feel confident that the contact may be worth while.

The American Society of Mechanical Engineers is affiliated with the A.A.A.S. through the Engineering Section, and by reason of this affiliation members of the A.S.M.E. may become members of the A.A.A.S. without payment of an entrance fee. The dues to the A.A.A.S. are $5 a year, and each member receives *Science* or *The Scientific Monthly* as he desires. Either of these publications

[1] Representative of the Associated Engineering Societies of St. Louis on American Engineering Council.

furnishes the engineer with valuable information concerning science and scientific achievements.

Members of the A.S.M.E. are entitled to attend the meetings of the Engineering Section without becoming members of the A.A.A.S., and an excellent program is being prepared for the coming meeting in Kansas City during the week between Christmas and New Year's, which will be announced in the *A.S.M.E. News*.

The problem of interesting engineers in the meetings of the Engineering Section of the A.A.A.S. is complicated somewhat by the intimate relations between engineers and their own societies. It should be clearly understood, however, that the important function of the Engineering Section of the A.A.A.S. is supplemental to and not competitive with the activities and meetings of the engineering societies. The Engineering Section provides the means for following the progress of science, and for the maintenance of relations with scientific men by those who practice professions based on science.

Patent Office Administration and Housing

TWO primary functions focus in the Office of the Commissioner of Patents. They are legal and administrative in character. The legal work, in essence, consists of holding hearings upon appeals from decisions of examiners and the Board of Examiners-in-Chief, and of writing decisions. The administrative work in character and quantity is similar to that of any organization having a thousand employees and some 60 subdivisions. However, in the Patent Office the work is more complex than in most organizations, hence the administrative problems are more difficult.

There are three primary executives charged with the responsibility of directing the legal and administrative work of the Office. They are the Commissioner and the two Assistant Commissioners. There is delegated to the Chief Clerk a large measure of responsibility associated with the purely clerical work of the office.

From the standpoint of the fundamental principles of management, the present plan is faulty. It is faulty because the three primary executives have two separate and totally unlike functions to perform: namely, legal and administrative. The legal-minded and -experienced man, as a rule, does not make an effective administrator. Likewise the executive-minded and -experienced man, as a rule, does not possess the qualifications required of a judge.

In addition to the violation of fundamental principles of management, another condition prevails that is conducive to ineffective administration. This is the amount of legal and judicial work the Commissioner and his two assistants are required to do. As a consequence the three of them actually spend less than the equivalent of one man's time on purely administrative work. They have practically no time to devote to a consideration of improvement of methods and policies. This in a large measure accounts for the backwardness of the Patent Office in regard to all those effective methods that are common-place in the modern industrial or commercial office.

Notwithstanding the conditions named, Commissioner Robertson and his staff have made some splendid improvements. They are keenly aware of the necessity of further changes, and their thought as to what should be done, and how, is sound.

The Chief Clerk is the fourth important link in the executive chain of the Patent Office. His duties are similar to those of a chief clerk or office manager in any large industrial or commercial organization. For some curious reason, some years ago Congress specified that the Chief Clerk should be a patent examiner. A patent examiner is first of all a technically trained man. In most cases he is also a graduate in law. At all events, he has prepared himself for a technical profession. To place a man of such training, experience, and objective in charge of clerical work is obviously a waste. The man becomes restive under such an assignment and either resigns or else obtains permission to return to his technical work. As a result of this anomalous policy, in less than five years four different examiners have served as chief clerks. This of course means that no real constructive guidance is being given the clerical work. Consequently it is not surprising to find that the methods used are antiquated and inefficient.

In view of the administrative situation, as briefly reviewed in the foregoing paragraphs, the Committee on Patent Office Procedure will recommend the following changes: namely, that

1 A sharp division be made between the legal (or judicial) and administrative functions centered in the office of the Commissioner
2 The Assistant Commissioners be selected because of their knowledge of patent law and procedure and because of their judicial temperament and experience. That to them be delegated the judicial work of the Commissioner's Office and that they not be required to exercise any executive or administrative functions
3 There be created a position of Administrative Assistant to the Commissioner, the same to be continued in office indefinitely. The Administrative Assistant under the direct supervision of the Commissioner, shall be responsible for all administrative and executive functions of the office and not discharge any of the legal or technical functions
4 The statutes be amended so it will not be a requirement for the Chief Clerk to be an examiner. The purpose is to select as Chief Clerk one who is making that field of endeavor his life work. The Chief Clerk will be under the direction of the Administrative Assistant.

The changes proposed will eliminate many of the present barriers to effective administration. They will also so relieve the Commissioner as to enable him to devote more time to the large matters of policy and progress.

Portions of the present Patent Office Building were first constructed in 1848. Subsequent thereto the building has suffered from two fires; has been added to and remodeled in many directions. The designer of the building accentuated facilities for displaying models. For purposes of a museum the building is admirable, but as a work place for 600 technical men engaged in examining applications for patents of a highly scientific character it is worse than a tent. As a work place for some 400 clerks it is wholly unsuited in every modern and economic sense.

The Patent Office now occupies 234,673 square feet of floor space, of which 111,390 are used as offices and work rooms, about 85,000 for files and storage, and the remainder for library, attorney's search rooms, etc. It is also using 23,136 square feet of space in the Land Office Building across the street from the Patent Office. It now urgently needs 10,000 additional square feet for purposes of relieving some particularly intolerable conditions. Even if this were available, the situation would not be corrected, as the personnel of the Patent Office has long since outgrown the available space, with the result that desks and files are located in out-of-the-way corners, in halls, and in corridors. From four to six people are endeavoring to work in small, ill-lighted, and badly ventilated rooms, which not only prevents economic production but is actually detrimental to health.

Due to insufficient floor space, too many people are in each examining division. Some examining divisions have twelve examiners working under one primary examiner. Every one familiar with the Patent Office recognizes that on an average a primary examiner cannot adequately direct the work of more than seven examiners. In order to reduce the number of examiners in each division and because of other important reasons, at least seven new divisions should be formed. These necessary changes cannot be made so long as the present housing conditions prevail.

The physical equipment, such as furniture, file cases, and the like, in the main, is obsolete in design and worn from use. Approximately 83 per cent of the copies of patents and 77 per cent of the trademark copies are filed on poorly constructed wooden shelves located in the attic, cellars, corridors, and halls. This is a serious situation from the point of view of economy of operation. Furthermore, these invaluable records are subjected to the worst sort of fire hazard. The stamina of American agriculture, commerce, and industry rests upon these records. Their loss would be a great calamity.

The wastefulness, the unsanitary conditions, and the risks due to the inadequate and intolerable housing conditions are generally recognized and understood. Under the present conditions of housing and equipment, economy of operation is unattainable. The work of the Patent Office can never be made as effective and as accurate as it should be until it is provided with ample and suitable

quarters and equipment. As long as the present situation prevails, American industry and commerce will continue to be impeded because of having to wait months for Patent Office actions. The Office now has approximately 50,000 applications pending. It requires at least six months to secure the first action on an application.

Commercial and industrial leaders, patent attorneys, and engineers are much concerned about the situation and are unanimous in the opinion that a new, modern building should be erected, and that it should be equipped with standard modern equipment. They are entitled to an efficiently housed, equipped, and manned Patent Office, because they bear all the cost of its operation. The Patent Office has earned above all appropriations more than $8,000,000, which amount has been used for other governmental purposes.

It is anticipated that the next session of Congress will pass an appropriation of $150,000,000 for Government buildings. The time is therefore opportune for those affected by and interested in the work of the Patent Office to make a united effort to secure for it the quarters and equipment required to fulfil the present demands for quality and quantity production. Until this is accomplished both the quantity and quality of work done will continue to be unsatisfactory.

L. W. WALLACE.[1]

The Engineer in Politics[2]

BY GEORGE H. DERN, GOVERNOR OF UTAH

IF THE engineer is to go into politics, as I think he should, I believe the curriculum of every engineering school should be amended to include a good stiff course in public speaking. My observation has been that the engineer in private conversation can scintillate as brightly as a life-insurance agent or an oil-stock salesman, but before an audience, with rare exceptions, he is a total loss. He will not get up and talk. He hides his light under a bushel, and sits on the bushel as dumb as an oyster. I have seen meetings of the Utah Section at which some topic of general interest to the members was up for discussion, and where an animated debate was the logical thing to expect. After the chairman states the subject and invites discussion, there is dense silence. Finally a member, bolder than the rest, gets up and with trembling voice and knees makes a motion. The motion carries, the meeting adjourns, and then the members gather into groups and begin to discuss the question seriously and intelligently, giving cogent arguments on either side and embellishing their remarks with appropriate or inappropriate epithets, illustrations and figures of speech.

Now, I am not pleading for more speechmaking. But I think every man ought to be able and ready to express his opinions at the proper time. The person who has ideas cannot exert any influence by keeping them locked up in his own mind. The great motive force of the world is not muscle, but ideas, and ideas in order to get in their work must be released.

The engineer, with his training of observation and analysis, ought to and does have ideas, and usually they are sound because they are founded upon facts and are carefully reasoned out. The world needs his ideas, and he ought to be equipped to express them at the time and place where they will do the most good. Perhaps I am presumptuous in urging engineers to be more vocal, but I think this recommendation has a direct bearing on my subject.

Politics is the science of government, and government is the science of human relationships. In other words, politics has to do with people. So long as the engineer remains in his own profession he has to deal almost exclusively with things—with inanimate matter. But when he gets into politics he has to deal with living, breathing, human beings. He must know something about how the human mind operates. He finds he cannot do anything for the public unless the public believes in him. He must "sell" himself to the public before they will follow his lead.

This is an age of specialists, and since engineering and politics are concerned with such different kinds of materials, it has come to pass that engineering is one specialty and politics is another, and it is only occasionally that the engineer, in a dilettante fashion, becomes active in politics. Possibly that is the first reason why the engineer in politics is conspicuous by his absence.

Why doesn't the engineer participate in politics? I suppose one reason is that he is too busy trying to make a living, and the fees in politics are not overly tempting. I am afraid, therefore, that I should be giving engineers bad advice if I advised them to go into politics for the money there is in it. However, it is well known that engineers do not care anything about money. All they want is a chance to serve their fellow-men, and so I feel safe in urging them to go in for politics.

An intelligent study of any question is properly commenced with definitions of terms. What is an engineer, and what is politics? Dr. George Otis Smith made the statement that an engineer is first of all a fact finder. I agree with that, and add that he must be willing to act in accordance with the facts as he finds them. I am content with that definition of an engineer for the present purpose.

There are two kinds of politics. The first is the science of getting office, and the second is the science of government. Both are important. It is silly to disdain seeking office, whether for one's self or for one's friends, for it is necessary to control the offices in order to accomplish anything in the direction of good government. The engineer in politics does not need to be an office seeker, but by giving safe advice and good counsel to those in office, he can be a power behind the throne.

It is a truism to say that by his training the engineer is exceptionally well equipped for public service. It is his business to get down to brass tacks, to find the facts of every problem, and to think straight. That is what we need in our public affairs. Too many politicians see a lot of things that do not exist, and others are unable to see things that exist. I heard a story the other day of two men who got hold of a couple of bottles of moonshine and went up to a room to drink it. After they had made good progress, and had obtained a high percentage of extraction from the bottle, one of them came downstairs in great alarm. He said, "Poor Bill has gone stone blind. There are snakes, squirrels and other things scrambling all over the floor, but Bill can't see any of them."

The engineer who can see clearly and whose mind is not fettered by a lot of hidebound traditions is exceptionally well equipped to solve public problems. Let me urge you to broaden out, and to do a little outside of your specialty of engineering. As a good citizen, you owe it to your community, and from my own rather limited experience I can recommend politics as a field where you can render valuable service, and honest service always yields satisfaction and pleasure.

The Basis of Prosperity

MANY expert and prominent men agree that the poeple of our country at present are highly prosperous and that there is good prospect of an even greater scale of prosperity. Just now there is a concurrence of many favorable conditions. The farmers have not done so well in more than five years. Alleviation of Federal taxation is assured. Governmental harassing of business has ceased. The courts repeatedly have upheld the rights of capital in the public utility cases. Improvement of railroad service has reduced greatly the quantity of goods in transit and consequently the lock-up of credit in them. Improved knowledge of economics keeps the situation free from the common practice of manufacturers, jobbers and retailers of overstocking goods on a rising market. The requirements of capital for extension of industrial plant are relatively small. Labor generally is contented. Its attitude is often irritating, but we need not mind that so long as it does not lead labor to loaf. The Locarno pact assures peace in Europe. Europe is taking steps to arrange its national indebtedness to us and thus rehabilitate its credit.

Business moves in an undulatory line. Its activity goes up and runs down. But to make it rise there must be reasons, and similarly there must be reasons for a fall. At the present time conditions that will produce a turn of the tide are not in sight.—*The Iron Age*, November 5, 1925, p. 1270.

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[1] Executive Secretary, American Engineering Council, Washington, D. C.

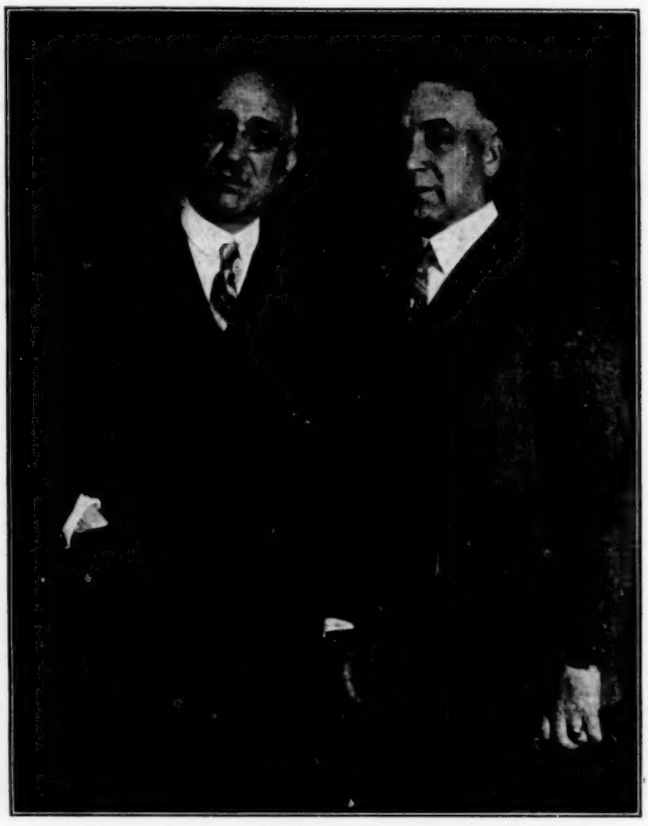
[2] From a speech made at the banquet of the American Institute of Mining and Metallurgical Engineers, during its Salt Lake City meeting, 1925, and published in *Mining & Metallurgy*, November, 1925.

Captain Ralph Earle Becomes President of Worcester Polytechnic

ON THURSDAY, Oct. 22, 1925, before a large and most impressive academic gathering, Capt. Ralph Earle, U.S.N. (Retired) was inaugurated as the sixth president of Worcester Polytechnic Institute. Captain Earle succeeds to the position left vacant through the retirement last spring of Dr. Ira N. Hollis, one of the past-presidents of The American Society of Mechanical Engineers, and an active member therein since 1884.

The exercises began at 9.15 a.m., when the academic procession formed in front of Boynton Hall and proceeded to the Alumni Gymnasium, where the inaugural exercises took place at 10.00 a.m. At 12.15 p.m. a reception was held at the president's house, followed by a luncheon for the delegates, guests, and officers of the Institute, which was held in the Gymnasium. Prominent speakers addressed the luncheon gathering.

The delegates and guests included representatives of more than fifty colleges and other educational institutions, among them several college presidents and official representatives of the Army and Navy, of the leading American scientific and engineering societies, and of industrial corporations which have founded scholarships. In the absence of Dr. William F. Durand, enforced by duties on the President's Aircraft Board, the A.S.M.E. was represented by Walter M. McFarland, Honorary Vice-President, who was one of the four speakers at the inauguration luncheon.



DOCTOR HOLLIS WITH HIS SUCCESSOR, CAPTAIN EARLE

At the inaugural exercises the introductory speaker was Rear-Admiral William V. Pratt. He bore upon the great part which the Navy has played in the history of the United States, and the keynote of his speech was the perpetuation of that sturdy Americanism which was exemplified by the traditional New Englander, who was at once a bold seafaring man, a brave fighter, and a law-abiding citizen.

The inaugural address of President Earle followed. This he opened with a historical sketch of Worcester Polytechnic Institute. He called attention to the facts that in 1868 it was brought into being in the heart of a region noted for its remarkable number of industrial pioneers, and that today its buildings stand on their hill in the midst of well-groomed parks, yet within sight of some of the leading industries of the world. In the fifty-seven years since its founding, graduates of the Institute have been in the forefront of the group of men who have developed these great industries so successfully.

In his plea for the broadening of technical education, President Earle said:

> We must be quite as liberal as the liberal-arts colleges claim to be. It is no easy task to plan a curriculum that will accomplish this. The youth of today faces a far more complicated world than did the youth of yesterday. Hence we must not be impatient, for we really do not understand his troubles. As students we knew little of electricity, or gas engines, or flying craft. The present-day student must learn of all of these and of many other things of which we never dreamed. And yet his main worry in life is the same as ours was: what shall he do to find his place in the world?

As to the engineering profession, President Earle had the following to say:

> Opportunity is open to the poorest and humblest youth, if he possesses the right material in his make-up. Engineering has ever presented fascinating problem that must be solved if civilization is to endure. The college that seeks to educate engineers must always feel the pulse of civilization, build for the future, and look ahead through the attractive field of research to anticipate the needs of civilization. Civilization ever demands improvement, and to know these needs close contact must be maintained between our colleges and the industries.

One of President Earle's deeply significant statements was:

> How many men have all the attributes requisite to the ideally successful man, yet just fail to reach the goal because they are not human! The world demands men who are human. In the nation at this time there is greater danger of civilization and government passing away than most of us see—or would admit if we did see. A true moral sense is needed to stop crime, disrespect for law, and disregard of high, gentlemanly standards. We need patriotism, love of home and of God.

The new president, like Dr. Hollis before him, is a graduate of the United States Naval Academy. He has, moreover, an extraordinary background of traditions which mark him as one predestined to play an important role in the history of Worcester Polytechnic Institute.

One of his ancestors, Pliny Earle, was an industrial pioneer of the Worcester district, and Stephen C. Earle, the eminent architect who designed Boynton Hall, the Salisbury Laboratories, the Mechanical Engineering Building and the Magnetic Laboratory of the Institute, was President Earle's father. President Earle closed his address by pledging himself to the spirit of the motto which his father placed upon the design of Boynton Hall, the Institute's first building. This was, "Prove all things; hold fast to that which is good."

Ralph Earle was born in Worcester in 1874, attended the public schools there and entered the Worcester Polytechnic Institute in January, 1892. A few months later he won, through competitive examination, an appointment to the United States Naval Academy. He entered in August, 1892, and was graduated in 1896. He was commissioned an ensign in May, 1898, and served as such through the Spanish War, participating in the two battles of Manzanillo as navigator and watch officer of the *Hornet*. He was promoted to lieutenant, junior grade, May 6, 1901; lieutenant, March 3, 1903; lieutenant commander, July 1, 1915; and chief of Bureau of Ordnance with rank of rear-admiral, December 23, 1916, being the youngest officer who ever held this responsible position. He served as chief of the Bureau of Ordnance throughout the World War and had to do with the arming and convoying of merchant vessels, the curbing of the submarine by the construction of the Northern Barrage, and the design and construction of the 14-in. 50-caliber railway batteries which cut the enemy line of communications in France during the last days of the war.

On May 5, 1920, he returned to sea duty as commander of the battleship *Connecticut*, with the rank of captain. He was made chief of staff of Control Force with the *Florida* as flagship on October 10, 1921, and on May 31, 1922, he took command of the Naval Torpedo Station at Newport, R. I. While he came to Worcester Polytechnic Institute last spring on a leave of absence, his official retirement from the Navy did not occur until August 25, 1925.

During his career in the Navy, President Earle had an unusual

practical training as an engineer, as an educator, and as an executive. He served as inspector of powder for the East Coast, was in charge of magazines and the chemical laboratory in the Philippines, was a member of the Special Board on Naval Ordnance, and was in command of the Naval Proving Ground at Indian Head. Between 1911 and 1913 he was at the Academy in Annapolis in the department of electrical engineering, physics, and chemistry, with the discipline department, and for a time as head of the department of English. Three years later he was again detailed to the Naval Academy to serve as head of the department of ordnance and gunnery, and at the same time as head of the department of English.

About twenty years ago, as a lieutenant, Ralph Earle was one of those commended for heroism in the rescue of survivors and in the prevention of the entire destruction of the battleship *Missouri* during target practice off Pensacola, when a terrific flareback and fire in the handling room cost the lives of five officers and twenty-seven enlisted men during target practice. Lieutenant Earle received personal letters from President Roosevelt and Secretary of the Navy Moody commending him for personal bravery in the face of that appalling disaster.

Subterranean Heat

Its Utilization as a Source of Energy in Italy—Developing Natural-Steam Wells in California—Thermic Calculation of Subterranean Heat

ON THE evening of Thursday, November 12, 1925, in the Auditorium of the Engineering Societies Building, a meeting of the Metropolitan Section of the A.S.M.E. was held which was of deep significance. To all practical purposes it was the first official recognition by an engineering society of national standing that subterranean heat may become a valuable source of power. As one of the speakers at this meeting pointed out, practically all sources of power which we are using today are in a way extraterrestrial and are largely transformations of solar energy. Water power is available because solar heat raises water from the level of the ocean and deposits it on land at a higher level, and thus enables it to return by gravity to the original lower level and, when properly harnessed, to do work on the way. Coal is a result of the growth of trees that would have been impossible without sunlight and solar heat, and while the mechanism of the formation of oil is still uncertain, here again the sun undoubtedly played a vital part.

It is only when we come to subterranean heat that we are beginning to deal with a source of truly terrestrial energy, the remnant of what might be called an inheritance of heat which our planet received in the very days of its formation, many hundreds of millions, perhaps billions, of years before the appearance of the human race.

As pointed out by John W. Lieb, Mem. A.S.M.E., who presided at the meeting, present-day civilization is due almost entirely to external energy created by the utilization of natural resources and developed by natural powers—water or wind power—or the stored energy of oil or coal. This era is truly the age of power, since we possess in this country nearly eight horsepower of mechanical power-producing machinery per inhabitant. Because the natural sources of power are small in comparison to our continually expanding requirements, we have been cautioned to conserve our stores of potential sources of heat, and the mechanical engineering profession has met the demands for efficiency by reducing in thirty-five years the consumption of heat necessary to produce energy from 150,000 B.t.u. per kw-hr. to 15,000, and even 10,000 B.t.u. is considered to be within the possibilities. Even this may not suffice, however. Meanwhile both in Europe and America the development of a new natural source of heat has been conceived and put into actual operation, and Mr. Lieb reminded the gathering that Plato, telling the story of the fabled Atlantis in his Critias, says (about 600 B.C.):

> Poseidon, as he was a God, found no difficulty in making special arrangements for the center of this island, bringing two streams of water from under the earth, which was caused to ascend as springs, one of hot water and the other of cold.

The meeting was addressed by Prof. L. P. Breckenridge, Dr. Geo. Otis Smith, and Messrs. J. D. Galloway, Geo. A. Orrok, and Frank A. Perret, extended extracts from whose contributions immediately follow.

Subterranean Heat as a Source of Energy

BY L. P. BRECKENRIDGE,[1] NEW HAVEN, CONN.

WHEN Dante, that great Italian poet, wrote The Divine Comedy, he placed hell at the center of the earth. Perhaps he had seen fire and brimstone issue from some of the peaks of Italy. Vesuvius, Etna, Stromboli, and Larderello are still hot spots in Italy, and the latter has been successfully utilized as a source of energy derived from subterranean heat through the work of Prince Ginori Conti.

Larderello is some 75 miles from Florence and is really a chemical plant where borax and other materials are made. Fuel for either power or heat has always been scarce in Italy. Here, however, steam is coming out from many spots with a hiss which won for them the Italian name of "soffioni."

The steam springs of Tuscany, where Larderello is located, differ from ordinary geysers, because they emit steam instead of alternate jets of steam and water. They are, in fact, typical steam springs, and water is only incidentally emitted or carried by the steam itself.

The steam contains a small percentage (0.1 to 0.3 per cent) of boric acid, and in 1827 Francesco Larderel conceived the idea of using the natural steam itself to concentrate the weak solution of boric acid.

The initial plant built at Larderello in 1912, after several years of preliminary experimental work, consisted of a turbo-alternator of 250 kw. capacity, running with a steam pressure of 0.5 lb. gage. The World War brought with it an insistent demand for power. By the beginning of 1916 new wells were drilled, a supply of steam of 260,000 lb. per hr. was under control, and the first of three new units, each of 2500 kw., was in operation. This also involved the building of two large cooling towers for the condenser water, as well as the installation of 22 Kestner evaporators, because up to 1923 the natural steam was not used directly in the turbines but was used to evaporate pure water for the turbines to avoid large quantities of objectionable gases in the surface condensers and corrosion of the turbine blades. The natural steam was circulated on the outside of aluminum tubes at a temperature of 250 deg. fahr. and generated pure steam on the inside of the tubes at a temperature of 230 deg. fahr. (21 lb. abs. pressure), so that by the time the pure steam reached the turbine the pressure was about 4 lb. gage.

At the same time research was carried on and important discoveries made which led to a change in the design of the plant. As Prince Conti stated in his paper at the Wembley Exposition in 1924:

> Since 1923 the evaporators have been abolished and an entirely novel manner of dealing with the natural steam has been adopted as the result of an extremely simple but very ingenious apparatus invented by my collaborator, Signor Bringhenti, by means of which it is possible to extract from the natural steam about 90 per cent of the gases which are contained in it. The result obtained is steam at a slightly lower temperature, but containing only 10 per cent of the original amount of gas.

[1] Professor Emeritus, Yale University, Mem. A.S.M.E.

It may appear at first sight that entirely pure steam would be preferable, and indeed such would be the case were it possible by the use of evaporators to insure a permanent and continuous supply of the said steam, but unfortunately, owing to the unavoidable damages to the evaporator tubes, caused by corrosion and other reasons, it is impossible to insure this uninterrupted supply, and for this reason ordinary evaporators are not entirely satisfactory because, owing to leakages, it often happens that natural steam and the accompanying gas find their way into the turbine and the condenser, thereby reducing considerably the vacuum on which the turbine mainly depends for its output.

It is therefore far better to reckon on a certain fixed percentage of gas, and to be able to rely on a constant vacuum.

The method used for drilling described in a paper by one of the engineers of the Conti organization, Cav. Ugo Funaioli, in *Engineering*, London, 1918, differs from that in use for boring artesian wells, the holes being lined with iron tubes welded together by oxyhydrogen flame. When the hole has reached sufficient depth a curious operation locally called "explosion" is performed. This operation, says the paper,

....is effected by introducing into the hole a sort of rough piston, which is subsequently withdrawn as rapidly as possible by means of the electric winch. If all possible conditions are fulfilled this provokes a small volcanic eruption, the hole emitting mud, stones, and boiling water, which are projected with the greatest violence and noise to a considerable distance, sometimes smashing the wooden structure erected over the hole and covering the roofs of the surrounding buildings with mud and stones. This eruption lasts for some minutes and is followed by the steady and continuous emission of dry steam escaping with a characteristic hissing noise.

The depths of the steam wells range from 60 m. (200 ft.) to 120 m. (400 ft.); in some instances a depth of 150 m. (500 ft.) has been attained before provoking the explosion.

Below are grouped for easy reference the essential elements, units, and capacities of the present (1925) Larderello plant. These cannot always be accurately given because of the close interrelation of the steam used for industrial and power purposes, but the the items given are approximately correct.

Steam Wells

1	Number of wells	12
2	Depth of wells	200 to 700 ft.
3	Diameter of wells	8 in. to 16 in.
4	Distance of wells from powerhouse	200 to 1000 ft.
5	Pounds of steam per hour at 15 lb. gage	264,000 lb.
6	Equivalent boiler horsepower on basis of 34.5 lb. per hr. at and from 212 deg.	9000

Steam Pressure

1	At top of wells with outlet closed	25 to 45 lb. gage
2	At top of wells when regulated for maximum flow	5 to 9 lb. gage
3	Available at turbine	3 to 5 lb. gage
4	Degree of superheat	50 to 100 deg. fahr.

Steam Turbines

1	Number of turbines	3
2	Type of turbines: Parsons—reaction—central feed	double flow
3	Speed of turbines	3000 r.p.m.
4	Capacity of each turbine	2500 kw.
5	Total capacity of plant	7500 kw.
6	Made by Messrs. Franco Tosi, Legnano, Italy.	

Condenser and Cooling Towers

1	Number of cooling towers	3
2	Bringhenti separators (replaced 22 evaporators)	3
3	Cooling surface each condenser	11,300 sq. ft.
4	Air pump	"water ejector type"
5	Circulating water	9300 gal. per min.

Electrc Generators

1	Made by	Brown, Boveri
2	Type	3-phase alternators
3	Voltage and frequency	4000 volts, 50 cycles

Up to the present time the addition of new wells has seemingly made no diminution in the flow from other wells.

In the course of the meeting the following cablegram was sent to Prince Ginori Conti, Larderello, Italy:

> The New York branches of our National Engineering Societies assembled in joint meeting discussing Utilization Subterranean Heat as a Source of Power send you their hearty greetings and felicitations as the world's great pioneer in this new field.
>
> (Signed) LIEB-BRECKENRIDGE.

The Internal Heat of the Earth

BY GEO. OTIS SMITH,[1] WASHINGTON, D. C.

A CONSIDERABLE amount of knowledge as to the temperature in the crust of the earth is being collected from an investigation of deep wells. Some of the latter go as far as one and a half miles into the crust of the earth. On the whole it would appear that the insulating properties of the earth's crust are much inferior to the asbestos lagging of commercial boilers. To compensate for this, however, the earth's crust is of enormous thickness. The result is that the loss of heat from the interior of the earth is extremely small and is estimated to occur at the rate of 1 deg. fahr. in a million years, thus testifying to the immensely great age of our planet.

The gain of temperature as we go down toward the interior of the earth is by no means uniform in various places. From present observations it would appear indeed that it varies from 1 deg. rise for each 26 ft. to 1 deg. for each 175 ft. It is very much slower in the old formations, such as the Atlantic Seaboard, and more rapid where volcanic action is still occurring more or less regularly, as on some sections of the Pacific Coast.

That there are enormous reserves of heat in the interior of the earth there can be no question. When it comes to utilizing them commercially, however, a good many difficulties are apt to arise. If, for example, a shaft were sunk to a very considerable depth, materials at high temperatures would be encountered. The chances are, however, that these materials would be rock, i.e., materials of low temperature conductivity, and the flow of heat to the shaft would be naturally very slow. Possibly, however, water might be used to collect the heat from a very large surface of the rock by creating some kind of a circulation.

Developing Natural-Steam Wells at the Geysers, California

BY J. D. GALLOWAY,[2] SAN FRANCISCO, CAL.

THIS paper describes the experimental-work done in the years 1922 to 1925 and gives accounts of tests and analyses made during that time. Several wells in all have been drilled and steam in large quantities and at a high pressure has been developed. The geysers lie on the northern bank of Big Sulphur Creek, a mountain stream flowing in a northwesterly direction into the Russian River. They are located about 75 miles due north of San Francisco in Sonoma County, in a region where there are many evidences of former volcanic activity. There are many boiling springs and steam jets or "fumaroles" where steam escapes directly into the air. The steam coming from an unknown depth heats the surface ground. The experimental wells were drilled at the Big Geysers, which cover an area of about 80 acres about midway in the extent of heated ground. In all there are five distinct areas where the steam is in evidence, the most eastern being the Little Geysers, covering an area of about 20 acres. While the area of hot ground at the different sites varies, the intensity of the activity is about the same at each place. The steam jets are about the same everywhere and the water in the springs has a temperature between 96 and 100 deg. cent. This water shows a mineral content of various salts.

A geologic reconnaissance of the region was made by L. C. Decius, geologist, and this would indicate that the nature of the country consists chiefly of Franciscan formation and of serpentine. The region is one of many faults, and the reason for the existence of the fumaroles and hot springs at the geysers is attributed to a weakened or fractured zone or fault through which both magmatic and meteoric waters find their way to the surface.

The present installation consists of four wells, and a fifth is being drilled. The existing wells are equipped with 10-in. steel casing, while for the new well a 15-in. outside and 12-in. inside casing is used. Data as to the history of the plant and methods of drilling are given in the complete paper.

Characteristics of the Steam. The steam pressure with the wells closed varies, and the same is true of the quantity of steam discharged under different pressures. Wells Nos. 6 and 7 have not

[1] Director, U. S. Geological Survey.
[2] Consulting Engineer.

been closed long enough to indicate the maximum pressure, but it is believed that it will reach 300 lb. per sq. in. After well No. 6 was brought in with an initial closed pressure of about 250 lb., the static pressure in other wells became greater. The following table indicates this.

	Wells					
	No. 1	No. 2	No. 4	No. 5	No. 6	No. 7
Initial static pressure, lb.....	64	67	82	143	240	198
Static pressure, September....	67.5	67.5	107	211	276	...

The data for well No. 7 will be completed later when devices are installed to allow the large valves to be operated under the anticipated pressures.

Numerous measurements of the quantity of steam flowing from the wells have been made. A considerable difference in quantity and pressure of steam is found in the different wells, the maximum static pressure being, for example, 111 lb. for No. 4, 276 lb. for No. 6, and 210 lb. for No. 5. In practice, since the wells must deliver steam into a common header, the quantity of steam from each well will vary. It has been calculated that the four wells now working will deliver 137,500 lb. per hr. at a header pressure of 75 lb. With a water rate of 27.5 lb. per kw-hr. condensing, these four wells representing a switchboard delivery of 4500 kw. after allowing 10 per cent for losses in steam in transmission. (All the pressures are gage pressures.)

The question might be asked why the wells are not drilled deeper, as the higher pressures and larger quantities are found at the lower limits of the wells. It can be answered that pressures up to 250 lb. and 300 lb. are high pressures. However, the principal reason for not going deeper is found in the nature of the ground through which the wells are drilled. It is naturally porous as shown by the surface steam vents. As the wells are only cased to a depth of about 200 ft., the higher-pressure steam from the lower depths is brought in contact with existing fumaroles of the upper rocks, and it might tend to open up an escape through some fissure in the upper rocks. Again, the seal of the casing against the rock is not absolute and there is danger of blowing out alongside of the casing or of blowing out the entire casing; such accidents having occurred in oil wells subject to high gas pressures. For these reasons it is believed that 300 lb. gage pressure is as high as should be developed.

As regards the effect of non-condensable gases in the steam on condenser operation and their effect upon a turbine, it is believed that a metal for turbine blades can be made which the gases will not attack. Coppers or alloys containing copper are, however, quickly eaten away by the gases. As regards the plant itself, estimates have been prepared for condensing and non-condensing plants, and it is believed that the problem presented by the non-condensable gases can be solved.

The development of steam and high pressures from the ground by wells is an unqualified success, and the extent of the territory gives promise of a large development. The permanence of the steam supply may be questioned, but the origin seems to indicate a long life to the project.

Thermic Calculation of Subterranean Heat

By GEO. A. ORROK,[1] NEW YORK, N. Y.

KELVIN years ago figured the period between the cooling of the earth's surface from 212 deg. fahr. to the present mean temperature of 53 deg., using the beautiful Fourier equation for this purpose, as in excess of 20,000,000 years. Since that time, however, radioactive phenomena have been studied with their attendant heat evolution and the period has been lengthened from ten to two hundred times. Such multipliers are a little upsetting where thermic calculations are involved, but let us make a few figures as to actual heat contained in the magma under various assumptions. Assuming the specific heat of the magma as 0.2, the heat content of a cubic mile over a range of 3000 deg. at 10 per cent efficiency amounts to 63,000,000 hp-years—and this calculation does not take into account the latent heat of solidification or crystallization of the magma, a quantity amounting to possibly 10 or 15 per cent of the figure given, nor does it take into account radioactive phenomena.

According to Joly, lavas ejected since 1631 contain as high as 77 lb. of radium per cubic mile. Rutherford's calculations show that this is nearly enough, if the proportion is constant throughout the earth's mass, to maintain the crust at a steady temperature.

Kaye and Laby give the total heating effect of radioactive mineral as 300,000 B.t.u. per second per cubic mile, or the equivalent of over 400,000 hp. continuously.

Thermic calculations based on the average gradient establish the fact that at 8500 ft. depth a steam temperature of 212 deg. fahr. could be maintained at the surface, and, with a suitable heat-transmission surface, a power delivery rising to over 100,000 theoretical horsepower at 25,000 ft. depth. At 150 lb. gage about half of this power could be obtained. Due to the use of heat and the cooling of the source, the output would be reduced according to a parabolic law until equilibrium was reached at a period involving hundreds of thousands of years. Apparently the equilibrium value is not far from 25 per cent of the maximum.

Maupertuis in the 18th century, and Sir Charles A. Parsons in the last few years, have advocated the sinking of a hole of this kind, and many estimates have been made of the surface necessary to be obtained for power purposes. Herbig, in a late German periodical, has given figures, based on the average temperature gradient, running from 100,000 to 300,000 sq. ft. of heat-transmission surface for 1 hp. continuously.

Similar calculations for better thermal conditions approaching the ideal might reduce these figures to as low as 257 sq. ft. of heating surface per hp. Another writer has called attention to the viscosity of the rock at high pressures and very reasonable temperatures. His calculations show that a 12-in. well 6000 ft. deep, the lower 3000 ft. being in a temperature above 212 deg., would only furnish enough heat to displace 200 lb. of good coal per year.

It is evident that much more may be expected from the fumaroles, soffioni, geysers, and other intrusive manifestations where the rock is porous or honeycombed, or where fissures may be found that communicate with the deeper and hotter portions of such intrusive outcroppings of the extensive magma layer.

In fact, the amount of steam issuing from the natural-steam wells in California and Italy is in excess of that which one might expect from the local temperature gradient and depth of well, and it may be concluded that the shafts tap subterranean fissures or porous rock which increases the available heating surface. These wells reach a depth of approximately 450 ft. and reach a rock temperature which computations show to be at around 400 deg. fahr. That fissures or porous material exists in the subterranean regions in California is substantiated by the fact that the static pressures of all wells was increased when well No. 6, which has the greatest static pressure of all, was capped.

Analysis of the output curves of natural-steam wells indicate that the active hypothetical surface of heat transfer is a function of the pounds of steam delivered per hour. This conclusion might seem extraordinary at first sight, but a little thought shows that the volume of subterranean passages drained is a function of the quantity of the steam delivered, and hence the active heating surface might be expected to vary with the steam output, and, therefore, with the steam pressure.

To each natural-steam well in a given locality there will exist a maximum area of heat transfer characteristic of itself. This maximum area has been determined for well No. 6 to lie between the limits of 300,000 sq. ft. and 600,000 sq. ft., which agrees very well with the figures previously given.

We have seen how a cubic mile of magma may contain the equivalent of many million horsepower-years, and, conversely, how a 6000-ft. well might perhaps only deliver the equivalent of 200 lb. of good coal, hardly enough to boil a teakettle for a month. Rutherford's figures, on the other hand, are very comforting and Flammarion's picture presaging the end of the world and a Paris cased in icebergs has almost faded from view.

At the worst we know that in favored portions of the earth's surface at least 10,000 kw. are being continuously produced from the subterranean heat of the earth, and that at another locality at least an equal amount of steam is available. We can, in any event,

[1] Consulting Engineer. Mem. A.S.M.E.

give expression at this time to the expectation of conquering, and of putting into leading strings, the vast plutonian forces which formerly manifested themselves in such spectacles as Vesuvius, Hecla, and Krakatoa, and of utilizing at least a small portion of this nearly unlimited store of energy for the benefit of mankind.

A Comparative Study of the Various Forms of Volcanism as Sources of Power

By FRANK A. PERRET, K. I. C.

THE author makes three principal distinctions between the surface manifestations of volcanic activities. First comes the true volcano, which means a vent of such size and permanence as to have continued active for a period of time which from our point of view is long and which has generally built up a mountain of the erupted materials around the vent. A volcano is supremely unreliable as a source of power. At one time which may be for hours, weeks, or months, it will release an enormously great amount of energy. Then again, for years it will sleep.

The "solfatara" is a region of far more moderate activity built up upon a true volcano, either as a result of the latter having become semi-extinct, or of some side or portion of it becoming so. The materials emitted are water vapor, volcanic gases, or hot water accompanied by sulphur and other low-temperature volcanic products. Solfatara of the trachitic variety of lava may maintain the condition of activity for a very long period of time. At the same time tests and observations would indicate that they suffer from some of the unreliability which obtains in the operations of the true active volcano.

The third manifestation is the geyser region, which forms where a great subterranean mass of igneous material has endured but never reached the surface to form a true volcano. If water exists in great abundance in the overlying terrain, geysers usually form, whereas if this is in lesser quantity there may be instead the so-called "soffioni," which are jets of steam containing more or less gas and chemical substances according to the nature of the contacts. The geysers appear to be the most nearly ideal source of available energy, because of their comparative reliability. In conclusion, the author imagines to himself Mother Earth broadcasting the following measage: "It is impossible that a world which has given birth to a race of men should not contain within itself everything which can possibly be needed for their welfare. Here are heat and light, and power in superabundance, but you must come and take it. Shades of Pluto, my children, bring on your engineers!"

A.S.T.M. Activities in Materials Testing

A SERIES of meetings were held in Cleveland by a number of committees of the American Society for Testing Materials on October 27–29, 1925. A large amount of work was done, but because of lack of space only the main conclusions can be told.

Among other things, a special committee was instructed to study the possibilities of combining the society's two specifications for structural steel for locomotives and structural steel for cars. At present the minimum tensile-strength requirements of the locomotive-steel specifications are 5000 lb. higher than the car-steel specifications. There is also under consideration the consolidation of specifications for structural steel for bridges and structural steel for buildings.

As regards tubular goods, a sub-committee is carefully considering whether specifications should not be graded somewhat according to the requirements of the wide variety of special services in which these goods are beginning to be used.

Specifications for cold-drawn automatic screw stock and commercial bar steels may be rearranged in such a way that hot-rolled and cold-finished materials will be covered by separate specifications, with possibly the inclusion of requirements for shafting in the latter specifications.

In the matter of pipe flanges and fittings a sub-committee reached the decision that the text of the specifications should refer to the fact that the material covered is intended for high-temperature service and should include in an explanatory footnote the statement that the specifications contemplate use of the material in installations up to 750 deg. fahr. and possibly higher temperatures, with suitable regard to requirements of design. In this explanatory note reference will be made to the pressure and temperature ratings that are being devised by the Sectional Committee on Pipe Flanges and Fittings functioning under the procedure of the American Engineering Standards Committee.

Modification of all wrought-iron specifications is being considered, looking to the revision of the requirements for tensile strength and elongation. The effect of phosphorus in wrought iron is being studied.

An important discussion was held by the Committee on Corrosion of Iron and Steel. The outstanding feature of the work of the Committee at this time is the elaborate series of tests on metallic coatings. The Committee is planning to expose to the weather metallic-coated sheets, wire, structural shapes, hardware, and the like at five localities stretching from Key West, Fla. to Sandy Hook, N. J., thus bringing a wide range of atmospheric conditions into the tests. A series of accelerated-corrosion tests are also being planned.

A value for yield point on malleable castings has been tentatively fixed at 30,000 lb. per sq. in., and the divider method of determining yield point has been specified as an alternative method.

A special research committee reported that the data so far obtainable on the effect of arsenic and tin on steel show that they are detrimental, but this may not be the case with respect to high-speed steels, in which large percentages of tungsten are used. Many of the tungsten ores contain varying amounts of arsenic and tin, but these two elements may act entirely differently in a martensitic structure, such as occurs in hardened high-speed steel, from the way they would act in low-carbon steel of pearlitic structure.

The question of tests to determine the effects of temperature on the properties of metals was discussed, and arrangements were made to carry out these tests with the hearty coöperation of outside organizations. The first set of tests is for the determination of the tensile properties of metals under elevated temperatures. Plans were discussed contemplating simultaneous work on other physical properties of metals at high temperatures, such as fatigue phenomena, erosion, etc. It is also intended to obtain reports from users of metals under severe service conditions involving abnormal temperatures, either above or below normal.

A sub-committee of the Committee on Non-Ferrous Metals and Alloys is at work on harmonizing its specifications for cartridge brasses with those of the Ordnance Department. Another sub-committe (on Light Metals and Alloys) wishes to present with the next annual report of the committee an article on duralumin and the newer light silicon-aluminum casting alloys (Modified Alloys). The organization of a new sub-committee on Wrought Zinc was authorized.

Several matters of interest were discussed by the Committee on Cement. The first refers to an intensive study of compression tests of cement made at a cost estimated to be upward of $10,000. This investigation was to confirm or modify the present A. S.T.M. tentative specifications and tests for compressive strength of Portland-cement mortar, and also possibly to furnish data which might assist in devising strength tests that may be completed in less time than the present 7- and 28-day tests. The Committee is alive to the importance of certain discrepancies which have been noted in these and other series of collaborative tests.

A sub-committee of the Committee on Coal and Coke (on Coördination of Coal-Ash Fusibility Tests with Clinker Formation) reported that active experimental work is in progress at the Bureau of Mines with a series of six coals whose ash fusibility ranges from 2000 to 3000 deg. fahr. Clinker tests are being made with these coals at various rates of combustion in a special experimental furnace in which conditions can be controlled. Gas analyses and temperature measurements are being made in various parts of the fuel bed. The effect of fusibility of "inherent" ash and distribution of ash-forming material in the coal is also being studied.

The Recommendations and Summarized Findings of the Committee on Civil Aviation

COMMERCIAL aviation in the United States, particularly as regards air transportation, has lagged far behind European developments. This national deficiency aroused the interest of Secretary Hoover of the Department of Commerce, and Governor Hartness of the American Engineering Council. Both these distinguished men came to the same conclusion, that a purely economic survey, quite distinct in character from the various political investigations of the aviation industry, might furnish a solution of the problem. Accordingly in June, 1925, a joint Committee of the Department of Commerce and of the American Engineering Council, was formed to make a comprehensive survey of the economic aspects of aviation throughout the world and to recommend the measures necessary to encourage its national development in the United States. The committee comprised: J. Walter Drake, Assistant Secretary Department of Commerce, Chairman; J. W. Roe, Past-President, Society of Industrial Engineers, Vice-Chairman; J. Parker Van Zandt, U. S. Army Air Service; W. F. Durand, President, American Society of Mechanical Engineers; E. P. Warner, Consulting Aeronautical Engineer; C. T. Ludington, Aircraft Operator; Luther K. Bell, formerly Traffic Manager, U. S. Air Mail; Alexander Klemin, Daniel Guggenheim School of Aeronautics, New York University; and E. S. Gregg, Chief Transportation Division, U. S. Department of Commerce.

The full report of the Committee is to be published at a later date but its recommendations and summarized findings have already been issued and contain a very interesting viewpoint They are presented here in abstract form.

Handicaps to Commercial Aviation in the United States

The Committee found that certain fundamental difficulties are retarding the development of civil aviation in the United States. These are summarized as follows:

1 The lack of a definite legal status and of government control

2 The lack of an established Government program to encourage the civil and industrial uses of aircraft

3 The lack of commercial aircraft and equipment best adapted to profitable commercial operation

4 The consequent lack of public and business confidence and support.

Recommendations

To remove these fundamental handicaps, the Committee makes specific recommendations, under the following subdivisions:

A—Legal Status and Control. The Committee recommends

1 That Congress enact a law providing for the establishment of a bureau of civil aeronautics in the Department of Commerce with power to regulate civil air navigation; to license pilots and register aircraft; to establish air routes and develop air-navigation facilities; to encourage civil air transport in general; to define the liability of common carriers; to reconcile the rules of water navigation with air navigation; and to correlate other laws with the carriage of goods and passengers by air.

2 That statutes be enacted authorizing municipalities to acquire and lease landing fields.

3 That the International Air Navigation Convention, which has been signed by the United States and ratified by most of the important countries, be ratified by the United States likewise.

B—Government Program Regarding Civil and Industrial Uses of Aircraft. The Committee recommends

1 That the Government do not engage in non-military flying activities which can be properly performed by private operation but extend the use of aircraft in some of its non-military activities such as air mail, forest patrol, agricultural, entomological, and Coast Guard services, etc., the operation to be conducted by private agencies under contract, wherever possible.

2 That the Federal Government provide such essential facilities as lighted airways, emergency fields, maps, radio, and weather service, and permit a reasonable use of Government landing fields for commercial aircraft operations.

3 That the Post Office Department encourage the extension of air-mail services, but should itself retire from the ownership of such services.

C—Commercial Aircraft and Equipment. The Committee recommends that the Government be authorized to purchase civil aircraft and equipment, in such a way as to give equitable compensation to the manufacturer for his experimental development work; that Government purchases conform to a definite and continuous program so as to give the greatest aid to the industry; that the Government should not compete with the industry in construction; and that the export of aircraft be facilitated.

D—Public and Business Support. The Committee recommends that aircraft underwriters base insurance rates to responsible operators on their record of performance rather than upon average figures including military hazards and the performance of irresponsible itinerant fliers; that life- and accident-insurance companies reconsider their position with regard to restriction on flying for their policy holders; and that financial agencies should invest in civil-aviation enterprises only after careful scrutiny of each proposition.

Findings

The Committee includes in its preliminary report a survey of the entire aviation situation in its Findings. These Findings on which the Recommendations are based may be summarized as follows:

Legal Status and Control

All countries actively interested in civil aviation, except the United States, have laws regulating the use of aircraft and requiring the licensing of pilots. Bills dealing with the subject have been introduced in every session of Congress for the past eight years. The one which has received the fullest consideration and widest approval is the draft prepared and adopted by the Committee on Interstate and Foreign Commerce of the House of Representatives, and is in substantial agreement with the recommendations of the Committee on Civil Aviation. The enactment of this legislation has been recommended by nationally representative organizations such as the National Aeronautical Association, the Chamber of Commerce of the United States, and the American Bar Association. The majority of manufacturers and operators of aircraft are also in favor of such legislation.

Because there has been no Federal legislation on the subject several states have passed laws and several municipalities regulatory ordinances. These laws and ordinances lack in uniformity and make the development of air transportation more difficult. That the regulation of civil aviation is a function of the Federal Government is demonstrated by the fact that the Conference of Commissions on Uniform States Laws has drafted a uniform state law for aeronautics.

Air services even now cross national boundaries. The International Air Navigation Convention (Paris, 1919) has been ratified by 22 nations. The Committee emphasizes the sad fact that until the United States ratifies this convention, aircraft from the United States may be barred from the countries which have ratified this Convention, and that the interests of its operators must certainly suffer if air regulations are drawn up by the permanent commission, now carrying on the work of the Convention, if the United States is not represented on this commission.

Air Transport in Europe and the United States

The Committee reviews and compares the situation in Europe and in the United States. European countries have not only assumed definite governmental control of flying, but have been active in providing the essential navigational facilities in the form of airways, beacons, etc. Direct subsidies have also been granted. These are not large (the aggregate amounts for England, Holland and France in 1924 were only $300,000) but have been an important help nevertheless. As a result air transport in Europe has extended rapidly as indicated by the following table:

In Europe	1920	1924
Number of transport companies	20	16
Length in miles of regularly operated routes	6000	15,270
Number of miles flown over regular routes	1,234,357	5,927,356
Number of pounds of mail carried	41,056	1,305,820
Number of pounds of express carried	482,230	3,802,241
Number of passengers carried	9,221	63,706

The situation in Europe is not entirely satisfactory. No European air-transport company is self-supporting, the highest actual earnings, those of the Europa Union, amounting only to 60 per cent of operating costs. Owing to the subsidies the rates are not in economic relation to operating expenses, and in general air transport is not on a sound business basis. Airways and navigation facilities are not yet entirely satisfactory and night flying is non-existent. A multiplicity of restrictions and regulations which accompany the subsidies are in many cases hampering sound development, and political complications are hindering international traffic.

The Committee then proceeds to give a somewhat depressing picture of conditions in the United States, where Government control and aid have not been adopted hitherto. After the war, commercial flying took two forms. The first and most prevalent was the operation of the "gypsy" fliers—mainly ex-pilots with little capital, cruising from city to city in their cheaply purchased war planes and giving the public "joy rides" from any available field. These itinerant operators flew 9,000,000 miles in the years 1921 to 1923, inclusive. In 1924 their flying decreased to about 1,000,000 miles; the flood of war material alone had made it possible for them to operate. In 1924 they had, owing to complete lack of control, the unenviable record of one fatality to less than 17,500 miles of flying, they created an impression of the great danger of flying in the public mind, and their numerous crashes also served to disgust the insurance companies with the writing of aviation policies. The responsible fixed-base operators have done better and are gradually finding a solid basis for their operations by developing such lines of work as aerial photography, rebuilding and overhauling ships, etc.

Nevertheless the Committee comes to the conclusion that there is hope for a greater development of commercial flying in the United States than in Europe. The reasons are interesting:

> Conditions in the United States are the most favorable in the world for commercial aviation, by reason of geographical extent, freedom from customs restrictions, unified political interests, common business methods, high standards of living and great activity in all forms of transportation. More letters are mailed and more goods moved per capita in the United States than in any other country, and there is a greater traffic between the Pacific and Atlantic States than between any two European countries. Topographical and meteorological conditions in the United States are also in general favorable to air navigation. The mountain ranges may hamper but do not preclude operation on the most probable routes, and prevailing weather conditions are better than in Western Europe.

The Committee states that direct money grants are neither wise nor necessary, but if civil aviation is to assume a business basis, air transport must be supplied with essential facilities analogous to those which have long been accorded to surface transportation. It is an interesting fact that Federal appropriations during the current fiscal year for waterway and highway transportation alone total about $200,000,000.

In spite of inadequate Government support the Committee points out that there are now substantial aviation projects taking shape. These are due in a large measure to the successful development by the Post Office Department of its day and night services, and to the passage of the Kelly Bill authorizing the carriage of air mail by private enterprise.

Industrial Uses of Aircraft in the United States

In the industrial uses of aircraft, as distinct from air transport, the Committee has much more encouraging Findings. It lists such items as the development of "cotton dusting" on a business basis, with a possibility of $135,000,000 annual saving to cotton growers. Aircraft is being used effectively for timber cruising, forest patrol, and in fighting forest fires. The United States Topographic Survey is planning to cover 44 per cent of its field work in 1926 by aerial surveying. The gross sales of the three most active photographic companies in the United States will amount to about $1,000,000 in 1925. The airplane is also being actively used in town planning, engineering projects, crop estimation, fisheries, etc.

United States Air Mail Service

The Committee summarizes the familiar facts regarding the wonderful growth of the Air Mail service, with the successful inauguration of night flying on the only permanently employed night airway in the world. Since its inception the Air Mail, up to July 1, 1925, has flown 9,839,000 miles and carried 261,987,120 letters. In addition to the New York—Chicago—San Francisco routes, the provisions of the Kelly Bill have allowed the Postmaster General to award five contracts for the carrying of mail by private operators, along the following feeder lines: Boston to New York; Chicago to St. Louis; Chicago to Dallas; Salt Lake City to Los Angeles; Elko, Nevada to Pasco, Washington, and seven additional lines are to be contracted for. Operators are to be paid entirely out of excess postage collected, so that the Post Office is relieved of financial responsibility. Contractors will therefore seek to develop air-mail traffic and this new system should certainly hasten the development of air transport. The Postmaster General has also clearly stated that it is the intention of the Post Office Department to relinquish control of the trunk lines.

Commercial Aircraft and Equipment

Since the armistice, the aircraft-building industry of the United States has dwindled lamentably. Engineering talent has scattered, special machinery has been scrapped, and 80 per cent of the capital invested has been withdrawn. The aircraft industry has suffered because its main source of support was in the form of Government orders for military aircraft, and because these orders have been placed without any plan or continuity. Design rights have not been sufficiently recognized by the Government. Aircraft design is expensive and insufficiently protected by patents; it has been a great hardship to manufacturers when the reproduction of advanced experimental craft has been obtained by open bidding. The Committee recommends certain measures to remove these handicaps, and also advocates that aeronautical research be continued, that Government competition in design and construction cease, and that dumping of aeronautical material similar to that in the early years after the war be not repeated. The aggressive export sales policy of aeronautical material by European countries could be followed, and the United States should certainly discontinue the prohibition of the exportation of commercial aeronautical material.

Aviation Insurance and Investment

The Committee urges the insurance companies to use greater discrimination in fixing rates to responsible operators as distinct from the gypsy fliers. It considers that aviation now offers a legitimate field of investment. But it sounds a note of warning. "Investors in aviation enterprises should be financially able to wait for dividends and to risk possible impairment of their invested capital. Investment should be made only with a thorough knowledge of the financing, operations, and personnel of aircraft enterprises."

A heavier-than-air machine involving in its design some of the principles of the airplane and some of the helicopter was developed some years ago by a Spanish engineer, Juan de la Cierva, who called it an "autogiro." It has a fuselage, propeller, and control devices essentially like an airplane, but instead of the planes it has a four-bladed affair capable of free rotation under the action of the stream of air coming from the propeller. The device was recently tested in England by representatives of the Air Ministry. It was found that it cannot hover over one spot but can both rise and descend in a nearly vertical line. At the end of the tests the machine was deliberately crashed in order to learn what would happen under conditions that would smash an airplane beyond repair and probably kill the pilot. The machine bumped against the ground rather badly and drove the undercarriage partly into the fuselage.

Engineering Graduates and Engineering Teaching Personnel

THE Society for the Promotion of Engineering Education has recently issued two reports[1] of a series which summarize many of the important facts relating to the present status of engineering education in the United States and Canada. The reports cover the two general subjects, engineering graduates and engineering teachers. This series of reports is a part of the general study of engineering education in which the Society is engaged under a grant of funds from the Carnegie Corporation of New York. The purpose of the study is first thoroughly to analyze the present situation in engineering education and, second, on the basis of the analysis so made to reach conclusions as to the profitable directions which efforts to improve engineering education may take.

The report on graduates is an endeavor to indicate the general situation as to the position in industry which graduates occupied during their early years after receiving their degrees, the fields of work into which they ultimately go, the means by which they secure positions and promotion, their earnings, their education after leaving college, and the views which they hold regarding the merits and deficiencies of their college work.

The report on engineering teaching personnel indicates the sources from which the colleges draw teachers of engineering, policies of institutions relating to the training and development of the younger teachers, the extent to which teachers engage in engineering practice, their earnings both from academic salaries and outside sources, and the extent to which the industries are taking well-qualified teachers from the colleges.

Other reports of the series which the Society for the Promotion of Engineering Education is publishing cover a considerable range of data regarding students at the time of admission, including their preparation, parentage, mental ability, scholastic records, reasons for choosing engineering, etc. Other reports deal with the high ratio of eliminations of engineering students from college and the causes of their failures, with the costs of engineering education, and other aspects of the college training of engineers.

H. P. HAMMOND.[2]

Report of Committee on Engineering Students and Graduates, June 1, 1925

THIS section of your committee's report relates to graduates of engineering and to former students who did not graduate. The bases of the report are the results of a questionnaire study undertaken at the invitation of the Board of Investigation and Coördination by a number of committees of the faculties of coöperating institutions. Individual questionnaires were sent by faculty committees to (1) recent graduates of the classes of 1924, 1923 and 1922, (2) to older graduates of the classes of 1919, 1914 through five-year intervals to 1884, and (3) to former students—non-graduates—of the classes of 1919, 1914 through five-year intervals to 1904. The reports of the faculty committees were abstracted and summarized by the office of the Director of Investigation.

Data have been supplied by a sufficient number of representative institutions to warrant fairly definite conclusions as to recent and older engineering graduates; while the returns on the former students—non-graduates—are so incomplete as to justify only the most general observations. Upon this basis your committee has given consideration to the following subjects developed by the report: distribution of engineering graduates as to general fields and special type of work; relation of field of work to course of study in school; earnings and progress of graduates; the placement process; opinions of graduates on engineering education; the continuation of study after graduation; and the former student—non-graduate—reasons for not finishing.

[1] Copies of these reports may be obtained for a small fee from the Society for the Promotion of Engineering Education, 33 West 39th Street, New York City.

[2] Associate Director of Investigation.

Occupation of Graduates and Relation thereof to Courses of Study in School

In Tables 1, 2, and 3, and Figs. 1, 2 and 3 are exhibited the most reliable and comprehensive statistics yet obtained on the important and much-discussed question of the actual occupation of graduates of engineering schools and the relation of lines of occupation to courses of study in school. Table 1 of the study of older graduates presents the general classification as to field of work of graduates who have already passed through the somewhat unsettled first five-year period, 25 per cent in the definitely professional field, 41 per cent in general industrial work, 16 per cent in commercial work, 13 per cent in governmental employ, and 5 per cent in financial work. In so far as any trend from one division to another is shown when graduates of longer standing are considered, the commercial and the professional group gain at the expense of the industrial group. On general considerations it seems unlikely that among the graduates of a given year more go into strictly professional work year by year, hence it is probable that this larger showing of the older classes in the professional group means that in former years the engineering graduate was more intent upon strictly engineering work, or else that for the older classes the replies were not representative, coming more largely from the men who have stayed in engineering work, and who might therefore have been more interested in replying to the questionnaire. However, the distinctly upward trend shown in Table 2 of the study of older graduates in the percentages of those entering the consulting engineering field with advancing years (2.7 in 1919 to 18.8 in 1889) tends to corroborate this.

TABLE 1 FIELDS OF WORK OF OLDER GRADUATES

		Classes of—					
		1919	1914	1904–1909	1894–1899	1884–1889	Totals
Industrial:	Number.....	158	276	363	164	24	985
	Per cent.....	35.8	45.9	43.5	40.7	23.8	41.3
Commercial:	Number.....	80	86	136	68	17	387
	Per cent.....	18.2	14.3	16.3	16.8	16.8	16.3
Financial:	Number.....	35	20	39	12	2	108
	Per cent.....	7.9	3.3	4.7	3.0	2.0	4.5
Professional:	Number.....	114	136	195	108	42	595
	Per cent.....	25.9	22.7	23.3	26.8	41.6	25.0
Governmental—Others:	Number.....	54	83	102	51	16	306
	Per cent.....	12.2	13.8	12.2	12.7	15.8	12.9

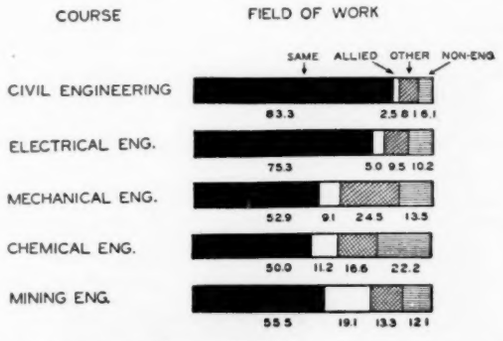


FIG. 1 RELATIONSHIP OF FIELD OF WORK TO COLLEGE COURSE—RECENT GRADUATES

Referring now more particularly to the type of work in its relation to courses of study, Figs. 1 and 2, we find for the recent graduates 59.6 per cent in technical engineering, 11.5 per cent in research and teaching, 16.2 per cent in administration and sales work, 7.2 per cent in clerical or manual work, and 5.5 per cent in miscellaneous types of work. The varieties of work of older graduates show 22.5 per cent in strictly technical work, 10.1 per cent in research and teaching (note the slight variation from recent graduates), 63.9 per cent in ownership, executive and administrative work including sales, and 3.5 per cent clerical and miscellaneous.

These figures show a healthy drift through technical work toward the responsibilities of management, and also indicate that engineering education to a satisfactory degree fitted the graduate definitely for his life's work.

Comparing the several branches of engineering on the basis of data given, the ratio of the number of older graduates remaining in the same or closely related line of work as their studies in school to the number of recent graduates so remaining, is:

	Per cent
Mechanical Engineers	101
Chemical Engineers	99
Civil Engineers	83
Electrical Engineers	71
Mining Engineers	67

TABLE 2 TYPES OF POSITIONS OF OLDER GRADUATES

		Classes										Totals	
		1919		1914		1904 and 1909		1894 and 1899		1884 and 1889			
Consulting engineer	No.	12		34		55		44		18		163	
	%		2.7		5.4		6.5		10.2		18.8		6.7
Design	No.	37		44		47		24		5		157	
	%		8.4		7.0		5.6		5.6		5.2		6.4
Estimating	No.	20		21		11		5		3		60	
	%		4.5		3.4		1.3		1.2		3.1		2.5
Drafting	No.	10		6		4		5				25	
	%		2.3		1.0		0.5		1.2				1.0
Operation and maintenance	No.	20		24		23		22		1		90	
	%		4.5		3.8		2.7		5.1		1.0		3.7
Testing and inspection	No.	28		13		5		5		2		53	
	%		6.4		2.1		0.6		1.2		2.1		2.2
			28.8		22.7		17.2		24.5		30.2		
Research	No.	30		26		23		18		1		98	
	%		6.8		4.2		2.7		4.2		1.0		4.0
Teaching	No.	33		23		61		24		7		148	
	%		7.5		3.8		7.2		5.6		7.3		6.1
			14.3		8.0		9.9		9.8		8.3		
Owner or proprietor	No.	24		66		121		81		19		311	
	%		5.5		10.5		14.4		18.8		19.8		12.8
Executive and administrative	No.	54		130		228		113		23		548	
	%		12.3		20.7		27.1		26.3		24.0		22.5
Management	No.	25		64		79		32		7		207	
	%		5.7		10.2		9.4		7.4		7.3		8.5
Superintendence	No.	53		83		105		33		5		279	
	%		12.0		13.2		12.5		7.7		5.2		11.5
Sales	No.	61		71		58		15		4		209	
	%		13.9		11.3		6.9		3.5		4.2		8.6
			49.4		65.9		70.3		63.7		60.5		
Clerical	No.	6		4		2		1				13	
	%		1.4		0.7		0.2		0.2				0.5
Miscellaneous	No.	26		17		20		8		1		72	
	%		6.1		2.7		2.4		1.8		1.0		3.0
			7.5		3.4		2.6		2.0		1.0		
Total numbers		439	100.0	626	100.0	842	100.0	430	100.0	96	100.0	2433	100.0

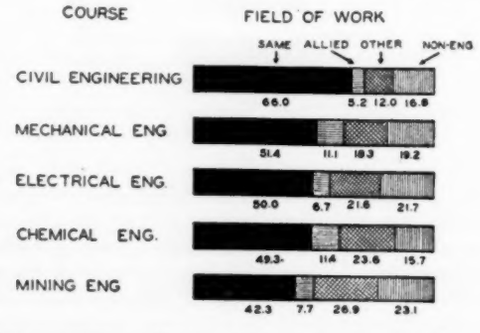


FIG. 2 RELATIONSHIP OF FIELD OF WORK TO COLLEGE COURSE, OLDER GRADUATES

It appears that mining engineering has the least security of hold on the graduate. It is not clear what the smaller number of recent graduates in chemical engineering and mechanical engineering staying in those fields means, whether temporarily there is a smaller demand for them in their special fields or a larger demand in unrelated fields.

EARNINGS AND PROGRESS OF GRADUATES

The study of older graduates shows a steady increase in the first year's salary except for the classes of 1889 and 1894 which corresponds to a period of profound depression in business. It would be of value to make a comparison of income increase in recent years with the decrease in the value of the dollar. For example, referring to Fig. 3 and Table 3, if we compare the entering salary of the class of 1914, $800, with that of the class of 1924, $1476, on the basis of a sixty-three cent dollar today, to normal in 1914, the recent graduate is more than holding his own. The earnings for recent graduates seem to be increasing steadily and satisfactorily, their progress being something over $300 in annual salary per year. Extreme variations between graduates of certain institutions do not appear, certainly no greater variation than would be expected due to the varying economic conditions in different parts of the country. The progress of older graduates seems fair although the rate of increase of recent graduates is not maintained.

DISCUSSION OF THE PLACEMENT PROCESS

Graduates in engineering obtained their first positions in the following manner: Through a teacher or other official of the colleges, 24.7 per cent; through the solicitation of an employer, 20.5 per cent; through work done prior to graduation, 15.7 per cent; through personal solicitation of employer by the graduates, 14.3 per cent; through family connection, 9.9 per cent; through the alumni of the colleges, 6.8 per cent; through advertisement or employment agencies, 5.6 per cent; and by other means, 2.5 per cent. It will be noted that but 45.2 per cent of all the graduates obtained their first positions through the organized efforts of the colleges or of employers.

The reasons given by the graduates for their choice of first positions are as follows: Because the work was in direct line of their college course or closely associated therewith, 49.5 per cent; apparent good opportunities, 25.8 per cent; only job available, 9.7 per cent; desired location, 8.7 per cent; good salary, 3.6 per cent, and other reasons, 2.7 per cent. The desire for the right sort of experience or of opportunity was evidently of far more influence than all others, being 75.3 per cent of the total. Contrary to general impression, perhaps, the question of salary was, ostensibly at least, a very minor factor. The figures show an excellent demand for men of engineering training.

The above relates to the first positions held. It is found that there is a very considerable shifting about from job to job among the recent graduates. Of the graduates of 1922, 57.0 per cent have held two or more positions since graduation, and 25.0 per cent of these have held three or more positions. Of the class of 1923, 39.5 per cent similarly held two or more positions, and 13.0 per cent held three or more. Even in a class graduating as recently as 1924, about 20 per cent have held two or more positions since graduation. The high degree of turnover indicated by these figures shows an unwise choice of first positions in altogether too high a percentage of cases. Of the graduates who do change positions many do not remain long enough in their first job to gain much experience or even obtain a clear conception of its ultimate possibilities. An undue amount of time is wasted by these graduates before they are established in their life's work. This high percentage of turnover among recent graduates could certainly have been reduced, it is believed, by more effective vocational guidance in the colleges. It is one of the encouraging signs of the time that some of our institutions have realized this need and are meeting it through the introduction of personnel systems and the selection of personal advisers, either from among the faculty or individuals specially designated for the work, and through more informal means giving to prospective graduates reliable information as to the various lines of work open to graduates. It must be admitted, however, that only a fair start has been made. It is also probably true that the methods employed by the industries in the selection of graduates are not yet as completely organized and scientific as they ought to be if the turnover of young engineering graduates in industry is to be reduced. Perhaps this is partly a problem of coordination of industrial and collegiate personnel methods.

In spite of the comparatively poor start made by many graduates, it is gratifying to note that 77 per cent express themselves as

satisfied with their present jobs, and 81 per cent as satisfied with their prospects, but even more important—that 95 per cent of the graduates express a definite liking for engineering work and more of them, 98 per cent, feel that they made no mistake in taking an engineering course.

TABLE 3 EARNINGS OF ENGINEERING GRADUATES

(Insufficient data to warrant determination of medians of the classes of 1889 and 1884)

Class of		Years since graduation 0	1	2	3	5	10	15	20	30
1924	Number reporting	1191								
	Median annual earnings	$1476								
1923	Number reporting	1331	1218							
	Median annual earnings	$1440	$1800							
1922	Number reporting	1149	1082	1023						
	Median annual earnings	$1320	$1800	$2100						
1919	Number reporting	319	319	304	274	309				
	Median annual earnings	$1300	$1800	$2000	$2200	$2860				
1914	Number reporting	496	475	458	436	444	498			
	Median annual earnings	$ 800	$1000	$1200	$1600	$2400	$4000			
1909	Number reporting	459	418	414	404	416	422	430		
	Median annual earnings	$ 720	$ 900	$1200	$1366	$1800	$3000	$5000		
1904	Number reporting	243	223	221	212	202	226	216	238	
	Median annual earnings	$ 720	$ 900	$1200	$1 300	$1530	$2500	$4000	$5500	
1899	Number reporting	156	126	125	123	125	130	129	147	
	Median annual earnings	$ 600	$ 800	$1075	$1380	$1600	$2700	$4000	$6000	
1894	Number reporting	119	97	96	92	109	102	103	100	116
	Median annual earnings	$ 600	$ 900	$1000	$1200	$1500	$2400	$3600	$5000	$7500

OPINIONS OF GRADUATES AS TO FEATURES OF ENGINEERING EDUCATION

The opinions of graduates seem to express general satisfaction with engineering education. As to the technical and scientific preparation for their work which they received in college, 76.6 per cent state it was either good or excellent. The importance assigned to the various general divisions of engineering curricula make for logical and natural sequence with scientific and technical subjects scoring much higher than economic and cultural subjects. The only thing of special significance is that economic subjects are put ahead of cultural. While the engineer needs general cultural education just as he needs good character, it is the scientific and technical part of his education that prepares him for engineering rather than for something else. The outstanding criticism of engineering curricula is the lack of courses in business and economics. Of the recent graduates, 50.9 per cent noted this as an important omission from their college courses, and in recommendation for improvements of in engineering courses, the inclusion of these courses also has a prominent place.

Opinions of older graduates as to the objectives of engineering courses were expressed as follows: To train broadly for the general needs of industry, 20.6 per cent; to train for specific needs of specialized divisions of engineering practice, 11.9 per cent; to provide the former type of training for the majority, but provide the latter type for those who desire to spend the additional time required, 67.5 per cent. This latter general notion held by so many indicates great need of study of the provision made at our engineering schools in this respect.

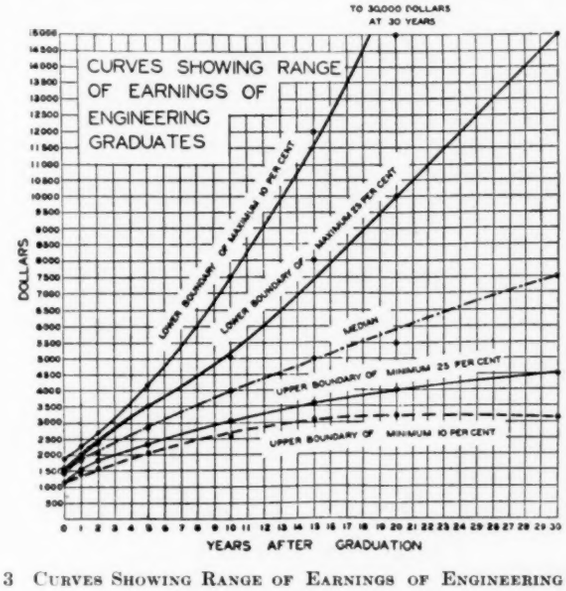

TO 30,000 DOLLARS AT 30 YEARS
CURVES SHOWING RANGE OF EARNINGS OF ENGINEERING GRADUATES
LOWER BOUNDARY OF MAXIMUM 10 PER CENT
LOWER BOUNDARY OF MAXIMUM 25 PER CENT
MEDIAN
UPPER BOUNDARY OF MINIMUM 25 PER CENT
UPPER BOUNDARY OF MINIMUM 10 PER CENT
DOLLARS
YEARS AFTER GRADUATION

FIG. 3 CURVES SHOWING RANGE OF EARNINGS OF ENGINEERING GRADUATES

THE FORMER STUDENT—NON-GRADUATE

As stated previously, the evidence before your committee on former students who did not graduate is not sufficiently complete to warrant more than general observations. On the basis of data available it would appear that about 60 per cent of the non-graduates drop out of college before the completion of their sophomore year, and the average length of residence appears to be 3.7 semesters or 1.8 years.

The predominant reason for leaving college has been given as financial difficulty in 24.3 per cent of the cases and scholastic failure in 22.7 per cent, while others follow with war service, 11.7 per cent; voluntary change of course, 10 per cent; lack of interest in engineering, 9.9 per cent; health, 8.0 per cent; and change in status of family, 6.4 per cent. War service, accounting for 11.7 per cent of the drop, is recognized as an unusual reason.

During the 1.8 years in college, but a small percentage of the men (5.3 per cent) claim poor health, the remainder stating that they had good or medium health. It is not apparent that health can be held responsible for any marked portion of the drop. Their participation in college activities (66.3 per cent report moderate or considerable activity) appears to have been considerable, particularly for men in the younger years, when they are not so likely to have become identified with college activities. The extent to which they were self-supporting does not appear to stand out beyond that of any other group of students. Complete self-support is reported by 24.3 per cent and more than half-support by 19.2 per cent. The remainder were self-supporting only to a small degree or not at all. The committee has not yet been able to reconcile these statements with financial difficulty as being the leading reason for leaving college. It appears probable that financial difficulty as a reason for leaving college may have been unconsciously emphasized in the minds of some for scholastic difficulties.

Of the causes of scholastic difficulty into which detailed inquiry was made, it appears that 55.6 per cent of the men acknowledged their difficulty to have been either poor scholarship or lack of aptitude on their own part. The blame was put on the school or the teachers by 23.2 per cent with such expressions as "Poor arrangement of the courses," "Poor presentation of the subject." The failure of 10.0 per cent more was found to be in the outside demands on their time such as the necessity for self-support and the time spent in commuting. Contrary to the usual opinion, at least in the minds of the non-graduates themselves, social diversions, athletics, and college activities have played a negligible part in the failures.

In analyzing the subject with which the greatest difficulty was experienced, it is found, as probably expected, that mathematics leads the list and is followed by the sciences and language. Mathematics or science is reported by 79.2 per cent of the non-graduate students as the subject with which the greatest difficulty was experienced. In general, the findings of faculties as reported by the committee on entrance and elimination agree with the facts here set forth.

CONTINUATION OF STUDY BY GRADUATES

The data on this subject are enlightening and seem to give evidence of a satisfactory carrying on of the intellectual stimulus received at college. Among the older graduates a gratifying number continued graduate work in a college or university—10.1 per cent. Of the remainder, 31.4 per cent have been devoting time to systematic study either under supervision or self-regulated. Such unsystematic study as the requirements of work have demanded has been carried on by 46.3 per cent. Only 7.6 per cent admit no study along technical lines.

Of the recent graduates the following facts are briefly given: 76.6 per cent of the positions occupied are such as to require study, while 23.4 per cent are not. Of those requiring study, 67.7 per cent are such as to require the student to continue along the specific or general lines of his college course. Approximately one-third of the studying is done under the supervision or direction of employers, while two-thirds of it is not. In two-thirds of the cases of positions

which did not require study, the graduates have nevertheless continued more or less systematic pursuit of some line of study. About 55.7 per cent of our graduates have continued their interest in the study of cultural subjects including literature, art, psychology, sociology, and the like. Here is evidence of systematic effort on the part of the graduate, the assumption of some measure of the responsibility of supervision by the employer, and a small contribution by the extension divisions of our colleges and universities. It might well be a matter for serious consideration whether or not our engineering schools should exercise more control over the intellectual life of their graduates by insuring well-directed study and a maximum result for the time and energy expended.

CONCLUSION

From the above discussion and the consideration of the data presented, it seems to your committee that there are several outstanding problems worthy of study by this society and the engineering schools and colleges of the country:

1 Study and development of better methods for guidance of graduates into industry
2 Possibility of supervision of technical studies of graduates in industry by engineering schools
3 Consideration of the expressed demand for more economic training in engineering curricula and better training in English
4 Consideration of the scholastic difficulties, which student and faculty agree are the chief obstacle to graduation of former students, with a view to decreasing the number of eliminations.

R. I. REES,
G. B. PEGRAM,
E. B. ROBERTS,
For the Committee.

Preliminary Report of the Committee on Teaching Personnel

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

Gentlemen: Your special committee appointed to coöperate with the Office of the Director of Investigation in the study of teaching personnel of the colleges of engineering presents herewith a first report. We submit the data collected, summarized in carefully prepared tables and will, with your permission, make comments thereon and point out such conclusions as seem justified at this time. The principal matters of importance in this report are the summary tables. The comments are intended only to focus attention on certain significant points.

I—PARTICIPATION OF TEACHERS IN ENGINEERING PRACTICE, DEVELOPMENT OF TEACHING STAFFS, ETC.

Professional Practice by Teachers during the Academic Year. The data indicate that teachers are permitted to engage in practice during term time in 96 per cent of the 116 institutions returning information. Only five institutions among the state universities and state land-grant colleges do not permit it. The practice is encouraged in 68.5 per cent, tolerated in 27.0 per cent, and discouraged in only 2.7 per cent of those institutions which permit it. [Two institutions (1.8 per cent) did not answer this question.] So few institutions impose any restrictions on such work, except that it shall not interfere with the teacher's regular work, that this appears to be the prevailing practice. The matter is in general left to the good sense of the individual, although in the case of the younger men there is some oversight by those in authority, some 14 institutions exercising some definite plan of supervision. The type of work which may be done does not seem to have come under close supervision. Fifteen out of the 111 institutions which permit outside work during term time definitely specify that the work must be such as to advance professional standing.

The fact that there are so few restrictions; that so many encourage outside work by teachers during term time; that there are definite arrangements in many institutions for the purpose of assisting the younger teachers to obtain such work; and that in general the individual members of the staffs are trusted to use their own discretion as to how much and what sort of work they shall do, seems to indicate that the practice is looked upon as a healthy one, and that it has not been abused. The evidence furnished by the tables showing data on supplementary incomes of teachers points in the same direction. The incomes from this source are moderate on the average, and unless the rate of pay is absurdly small the total bulk of outside work can hardly be regarded as sufficient to present any really serious problem—this remark applying, of course, to the situation as a whole. The practice seems to afford teachers a desirable opportunity to keep in contact with current practice. This is an advantage in their teaching work, broadens and enlivens their interests, and furnishes additional income which doubtless tends to make them contented with their positions. Much of the outside work leads to results of general technical value and redounds to the credit of the institution and to those who participate in it.

Arrangements for Use of Laboratories by Teachers for Outside Work. This subject is related closely to the previous one. Only three of the institutions which permit outside practice by members of the teaching staff do not permit the use of college laboratories in connection with such work. In 44 per cent of the institutions which do permit the laboratories to be used, materials and certain other costs are paid for by those who use the laboratories. In 40 per cent of the institutions a fee is charged in addition for the use of the laboratory. There are also certain other special regulations. It is to be noted that in only one institution, as far as known, is any definite attempt made to fix a charge for use of the laboratories for overhead computed as a certain percentage of labor costs. Why should the institution not be reimbursed, not only for materials and labor used but for overhead? The latter is usually unknown, but probably cannot be less than 50 per cent of labor cost. Probably the volume of work has not been great enough to be a serious item, and has simply been allowed to go into the general expense account of the institution.

Use of Name of Institution in Connection with Outside Work. Approximately 80 per cent of the colleges look upon the individual doing the work as solely responsible for results, and institutional responsibility is disclaimed or expressly denied. Ten per cent state that the professor may state his identity with the institution, though this probably does not imply any responsibility of the institution for the results of the work. The institutions having experiment stations send out official reports confined to data but give no opinion or guarantee as to its value.

In general it appears that the engineering colleges avoid any official connection with industrial work but act rather as true public-service institutions placing, so far as practicable, their facilities—including teachers—at the disposal of their public, allowing the staff to render service on their own responsibility of the mutual benefit of all concerned.

Assistance to Younger Teachers in Broadening Their Experience. Of the 116 institutions reporting, 79 per cent give such assistance while 18 per cent do not. Apparently there is a strong tendency to assist younger teachers to secure vacation employment. One institution, the New Mexico College of Agriculture and Mechanic Arts, not only makes an effort to place its staff in vacation work, but actually provides financial assistance to members of its faculty for pursuit of courses of study, etc. A few others make similar arrangements through grants from endowment funds. This is excellent for the younger men.

Sabbatical Leave. Sixty-five per cent of the institutions have no policies as to sabbatical leaves for teachers of engineering. Thirty-two per cent of the institutions have policies of varying types. The frequency of permitted leaves varies from one-half year in three to one year in eight; the term sabbatical evidently not being confined to its strictly derivative sense. Salary during leave is usually adjusted on the basis of half-year with full pay or full year on half-pay.

It is rather significant to note that only 77 leaves of absence of all kinds have been taken by teachers of engineering in the past five years. This number is in 116 institutions having a total faculty of perhaps three thousand members. The rate is about 15 individual leaves per year, or about 0.5 per cent of the total number of teachers. It would be interesting to know how these figures compare with those for college teachers in other lines. It seems pos-

sible that teachers of engineering avail themselves of sabbatical leave to a lesser extent than other teachers. If there were more demand for such leaves it is probable that the practice would be more general among the colleges, and it is probably the fact that engineering teachers supply the want of leaves of absence through the practical engineering work which they carry on during the college year and in vacations.

Instruction in the Art of Teaching. Your committee were led to ask for data on this subject because they were conscious that there is constant criticism from certain sources that the art of teaching is neglected in the engineering colleges and that men are hired to teach rather because of their knowledge of the subject than their ability to impart it to others. The returns indicate that 85 per cent of the schools give no systematic instruction in the art; 5 per cent answer in the affirmative for all departments; 5 per cent state that such instruction is given in some departments; and about 5 per cent did not reply to the question. In connection with this matter it is to be noted that in 21 per cent of the institutions it is customary for the older teachers to visit the classrooms of younger teachers, and that in 33 per cent it is customary for the younger teachers to observe the methods of older teachers. About three-fourths of the faculties seem to feel that such instruction is or could be made of substantial value; about one-fifth feel otherwise. The general impression is that there is apparently a rather mild feeling that some sort of instruction might be made of value, but there is much doubt as to whether or not anything worth while can be done, or, if it could be done, who should do it and how. It seems to be a rather general impression in the engineering colleges that good teachers are born, not made, and that the poor teachers can be eliminated quite easily. It is evident from the replies that departmental conferences on methods of presenting particular subjects are generally the practice, and although the amount of this varies widely it really constitutes in its entirety a method of great instructional value.

We venture to comment on the fact that, although not specifically asked for in the questionnaire, all mention of instruction in the art of speaking and behavior in the classroom was conspicuously absent in all replies. We venture to express the opinion that young teachers could be greatly helped by some instruction in the art of speech, and in the matter of their actions and behavior before classes. If a teacher is obviously master of his subject, has his material well arranged, and possesses a strong and pleasing personality, he may get by even though he has serious faults of speech or manner; but these nearly always lessen his effectiveness, sometimes very seriously. Such faults may become serious drawbacks to success and they might often be easily corrected by a little tactful criticism and advice offered when the teacher is young.

TABLE 1 ACADEMIC SALARIES AND SUPPLEMENTARY INCOMES OF TEACHERS OF ENGINEERING IN THE UNITED STATES AND CANADA

2279 individuals reporting. 75 institutions represented, as follows:
23 in New England and Middle Atlantic States, 5 in Canada,
10 in Rocky Mountain States, 13 in Southern States,
4 in Pacific Coast States, 20 in Middle Western States.

Years since first degree was obtained, as of June, 1925	Total number reporting	Individuals reporting supplementary incomes		Annual academic salaries		Median annual supplementary incomes of those reporting same	Annual total incomes[1]	
		Number	Per cent	Median	Most frequent		Median of those reporting supplementary incomes	Median, all individuals included
1	76	53	69.8	$1,500	$1,800	$ 300	$1,900	$1,750
2	115	71	61.7	1,700	1,800	400	2,000	1,900
3	101	59	58.5	1,800	2,000	325	2,100	2,000
4	110	65	59.0	1,900	1,800	393	2,400	2,200
5	108	69	63.9	2,000	[2]$1,800–2,000	483	2,700	2,400
6	83	59	71.1	2,225	2,000	550	2,900	2,675
7	75	55	73.4	2,200	2,000	500	2,850	2,700
8	93	64	68.9	2,400	2,400	600	3,100	2,850
9	71	53	74.6	2,400	[2]$2,400–3,000	600	3,075	3,000
10	118	91	77.1	2,550	3,000	625	3,300	3,075
11	83	66	79.5	2,800	2,700	679	3,550	3,300
12	75	60	80.0	2,850	2,500	700	3,750	3,550
13	61	51	83.6	3,000	3,000	600	3,550	3,500
14	90	80	88.9	3,000	3,000	600	3,525	3,450
15	81	69	85.2	3,000	3,000	795	3,900	3,800
16	63	48	76.2	3,000	2,800	800	4,150	4,000
17	82	73	89.0	3,200	3,000	600	4,000	4,000
18	70	63	90.0	3,300	3,000	880	4,200	4,050
19	61	53	87.0	3,600	4,000	720	4,850	4,550
20	86	77	89.6	3,500	4,000	1,200	4,875	4,600
21	43	37	86.1	3,625	[2]$3,500–5,000	1,000	4,900	4,500
22	52	42	80.8	3,500	[2]$3,000–4,000	1,210	4,800	4,700
23	35	30	85.7	4,000	4,000	1,350	5,400	5,250
24	52	45	86.5	3,700	3,500	1,000	4,750	4,500
25	42	38	90.5	3,600	4,000	1,000	4,600	4,500
26	25	24	96.0	4,300	[2]$4,500–5,000	1,550	5,300	5,250
27	26	26	100.0	4,225	[2]$3,500–4,500	1,700	5,750	5,750
28	25	22	88.0	4,500	5,000	1,475	5,700	5,550
29	34	31	91.3	4,000	4,500	1,375	5,850	5,500
30	47	37	78.7	4,400	5,000	1,700	6,700	5,600
[3]31	25	22	88.0	4,225	[2]$4,500–5,000–6,000	1,550	6,000	5,825
[3]32	21	21	100.0	4,200	5,000	1,800	6,550	6,000
[3]33	15	12	80.0	4,225	4,000	1,350	6,000	5,825
[3]34	22	20	91.0	4,275	4,500	1,650	6,000	5,725
[3]35	21	18	85.7	4,400	4,500	1,377	6,000	5,600
[3]36	11	10	91.0	4,500	4,500	1,200	5,650	5,150
[3]37	12	10	83.3	4,500	4,500	1,000	5,500	5,400
[3]38	11	10	91.0	4,500	4,500	1,333	6,000	5,950
[3]39	10	9	90.0	4,650	[2]$4,500–6,000	1,402	6,600	6,000
[3]40	14	13	93.0	4,800	6,000	1,775	6,800	6,600
[3]41	7	6	85.7	5,000	6,000	2,100	7,500	7,250
[3]42	6	6	100.0	4,800	6,000	2,000	6,800	6,600
[3]43	5	4	80.0	5,000	6,000	1,800	7,500	6,400
[3]44	3	2	66.7	4,800	6,000	3,000	6,000	6,000
[3]45	1	1	100.0	4,500	[2]$3,000–4,000 5,000–6,000	2,100	6,250	6,500
46	2	2						
47	4	3						
48	2	2						
49	1	1						
50	0	0						
51	1	1						
52	0	0						
53	1	1						
54	0	0						
55	1	0						

Medians have not been computed because of small number of individuals

[1] For calendar year 1924.
[2] Equal numbers of salaries of amounts shown reported.
[3] Medians computed for five-year period.

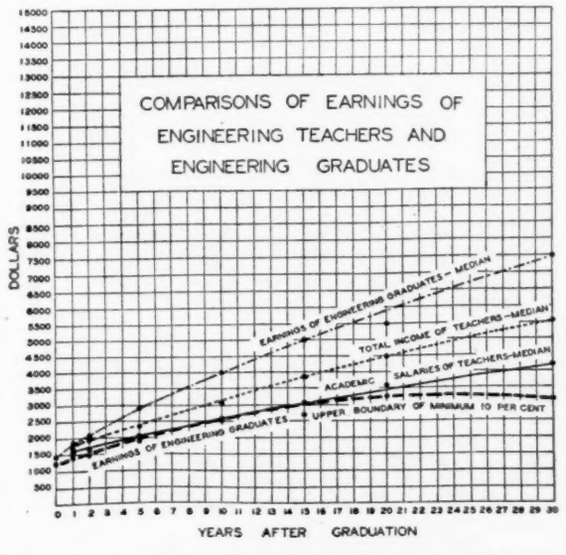

COMPARISONS OF EARNINGS OF
ENGINEERING TEACHERS AND
ENGINEERING GRADUATES
DOLLARS
EARNINGS OF ENGINEERING GRADUATES – MEDIAN
TOTAL INCOME OF TEACHERS – MEDIAN
ACADEMIC SALARIES OF TEACHERS – MEDIAN
UPPER BOUNDARY OF MINIMUM 10 PER CENT
EARNINGS OF ENGINEERING GRADUATES
YEARS AFTER GRADUATION

FIG. 1 COMPARISONS OF EARNINGS OF ENGINEERING TEACHERS AND ENGINEERING GRADUATES

The comments from various schools on the matter of instruction in the art of teaching which are given in the complete report are worth reading. They give an excellent cross-section of opinion and practice on this subject.

Use of Men Regularly Employed in Industry as Auxiliary Teachers, and Instruction Given to Employees of Industries by College Teachers. As a part of the investigation it was decided to learn to what extent the engineering colleges make use of men regularly employed in industry as part-time teachers in the schools, and also to learn to what extent the colleges coöperate in educational work done by the industries for the benefit of their employees. It is learned that about one-fourth of the colleges use men from the industries as part-time teachers, and that an equal proportion (though not necessarily the same institutions) supply teachers from the staffs to assist in carrying on educational work for employees. The general opinion is that both of these practices are valuable to a certain extent. It is noted by some institutions that care must be exercised in correlating the work of the man from the industry with the work of the regular staff, and in keeping him from going over the head of his class. The outside man may often be inspiring and may present new points of view to the class, but we infer that instruction of this sort is to be regarded as an auxiliary to, rather than as a substitute for, regular staff instruction.

II—Study of Salaries and Supplementary Earnings of Engineering Teachers

The results of this study constitute a very successful attempt to picture the financial status of a particular class of individuals. About 2850 questionnaire cards were distributed to members of the staffs of 75 representative institutions throughout the United States and Canada. Eighty per cent of those canvassed, or a total of 2279 individuals submitted responses which are compiled in the tables. This does not include about 70 cards improperly or incompletely filled out or a number of cards received after the tables and charts were prepared. It is believed that the figures given in the summary tables are quite reliable and furnish an entirely trustworthy cross-section of the financial situation of the teachers of engineering as that situation exists to-day. It may be that a few very large supplementary incomes have not been reported, but since results are reported as medians, it is not likely that these few cases would materially affect the results. In this connection it may be noted that there are a considerable number of incomes in excess of $10,000 per year included in the results.

The figures for maximum and minimum salaries call for little comment. It is possible that the exceptionally low salaries of some individuals of long periods of service may represent shop instructors, or possibly even teachers on part-time, though it was not intended to include the latter.

TABLE 2 STUDY OF ACADEMIC SALARIES AND SUPPLEMENTARY INCOMES OF TEACHERS OF ENGINEERING IN 69 REPRESENTATIVE INSTITUTIONS IN THE UNITED STATES AND CANADA

Rank	No. of each rank reporting	Maximum	Minimum	Median	Most frequent
Dean	54	$10,000	$2,500	$5,000	$5,000
Professor	700	7,500	2,500	4,000	4,000
Associate Professor	350	6,000	2,000	3,300	3,500
Assistant Professor	539	5,000	1,500	2,700	2,500
Instructor	831	3,000	900	2,000	2,000
Assistant	137	2,400	250	800	800
"Associate"	20	4,500	2,200	2,500	2,500
	2,631				

Aa4—A Study of Engineering Graduates) afford a basis of comparison with the earnings of engineering graduates in practice. Fig. 1 shows the ratio of salaries of teachers of engineering to those of graduates. At the start the teachers salary and total earned income exceed the earnings of graduates by a small amount. At the end of one year their total incomes are practically equal. After one year the teachers earn steadily less than graduates in practice, until at the thirtieth year after graduation the total earnings of teachers are but 74 per cent of those of graduates in practice. When academic salaries—either median or most frequent—are made the basis of comparison, the status of the teacher as to earnings is, of course, still less favorable. The young teacher beginning his career must, it appears, look forward in general to a smaller income than if he went into practice—assuming that his earning capacity in industry is proportionately as great as it is in teaching. There are two comments which might be made on this situation: one, the oft-stated compensations pertaining to the career of a teacher (though some question whether these are more imaginary than real), and the second, the difficulty of recruiting able teaching staffs with the handicap of small compensations than can be earned in practice.

Table 2 presents a summary of salaries arranged according to teaching rank. This table includes 69 of the 75 institutions included in Table 1. The institutions have been carefully chosen and probably give a reliable cross-section of salary levels throughout the United States and Canada. The small median and most frequent salaries of deans and professors are striking. If we compare these salaries with those on the basis of years since graduation, using the most frequent salaries as an index, we may conclude that teachers reach the grade of assistant professor in about eight years, the grade of associate professor in about 15 to 20 years, and that of professor in from 20 to 25 years.

Sources from Which Engineering Teachers Are Obtained. The figures summarized in Table 3 show that a majority (67.1 per cent) of teachers of all ranks are obtained through promotion from graduating classes and from the teaching ranks, so that the body of our staffs is built up from this source. There is a substantial interchange between schools, ranging from about 11.4 per cent in the case of assistants to about 37.5 per cent for deans, the average being about one-fifth for all grades. There is also a notable proportion of teachers derived from engineering practice, ranging from about one-fifth for the professorial ranks to about one-third for instructors. We believe these figures show a satisfactory state of affairs; that they relieve us of the accusation of inbreeding within individual institutions; and that they give assurance of a substantial and healthy leaven from the ranks of the engineering profession.

TABLE 3 SOURCES FROM WHICH TEACHERS WERE OBTAINED

(Figures give the numbers obtained from each source during the calendar years 1920 to 1924, inclusive)

Rank		By promotion in staff in same institution	From staff of another institution	From graduating class of same institution	From graduating class of another institution	Total from teaching staffs or graduating classes cols. 2 to 5 incl.	From engineering practice	From other sources	Totals cols. 6 to 8 incl.	Present numbers of each rank in institutions represented
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dean:	No.	16	12			28	4		32	70
	%	50.0	37.5			87.5	12.5			
Prof.:	No.	83	47			130	37	8	175	487
	%	47.4	26.8			74.3	21.1	4.6		
Assoc. Prof.:	No.	104	30			134	34		168	207
	%	61.9	17.9			79.8	20.2			
Asst. Prof.:	No.	163	112	14	5	294	79	7	380	376
	%	42.9	29.4	3.8	1.3	77.4	20.8	1.8		
Instr.:	No.	57	178	223	117	575	334	59	968	630
	%	5.9	18.4	23.1	12.1	59.4	34.5	6.0		
Asst.:	No.		9	26	21	56	21	2	79	94
	%		11.4	32.9	26.6	70.9	26.6	2.5		
Unclassified:	No.	1	18	26	1	46	19	17	82	84
	%	1.2	22.0	31.7	1.2	56.1	23.2	20.7		
Totals:	No.	424	406	289	144	1,263	528	93	1,884	1,948
	%	22.6	21.6	15.3	7.6	67.1	28.0	4.9		

The percentages of instructors and assistants secured from other institutions deserve comment. The numbers are due in part doubtless to a policy of securing men with varied training and experience, but they are also probably connected with a tendency on the part of the young men themselves to gain experience, or to pursue further study at an institution other than the one from which they graduated. Whatever the cause, it is a healthy situation, pointing as it does to a large circulation of young men among the schools.

The return of young men from industry is also probably on the whole a satisfactory state of affairs. There are probably many of them who desire to get a more thorough grasp on theory and plan to do graduate study along with their teaching. They should come back from industrial work with a broadened viewpoint and a clear idea as to what is important in education. We should not overlook the fact, however, that some of these young men come back because they find industrial work not to their taste, or the pace faster than they can maintain. An uncertain proportion of them are perhaps of doubtful value.

It is significant to note from Table 3 that the number of new men added in a period of five years to the staffs in ranks below that of

Of the 2279 individuals reporting, 1785 state that they have supplementary incomes, the percentages for the various ages ranging from 58.5 to 100, with an average for the entire group of 78.5. There is a gradual increase in this percentage, with minor fluctuations. The median supplementary incomes show a gradual increase throughout the period, reaching a maximum median figure of $2000 per year for those who reported supplementary incomes. There is a noticeable but unexplained sudden increase in the supplementary incomes at the twentieth year after graduation. Preceding this year the incomes from supplementary sources range from $600 to $880 per year. At the twentieth year there is a sudden increase of $1200 per year. From this point on the supplementary incomes in four figures continue. The supplementary incomes rather rarely reach one-third of the median or most frequent salaries. On the whole the supplementary incomes are modest in amount and controvert the statement so often heard that engineering teachers earn large sums from engineering practice.

The data of this and other studies (see Summaries of Project

assistant professor exceeds the number of men holding such positions at present. It is evident that there is a considerable shifting of teaching personnel in the lower ranks.

Losses of Teachers to Practice and Industry. Commenting on the losses during the five-year period covered by Table 4 (1920 to 1924, inclusive) it appears that the annual turnover for all grades of teachers and for all changes of positions is about 10 per cent. The actual annual loss of teachers by the institutions is about 6.75 per cent. In the grades of instructor and assistant the percentage of losses is much larger than in the professorial grades—11.5 per cent as compared with 3.35 per cent. The total percentages of teachers who change their positions per year to go too their institutions or to leave teaching are as follows: to take another teaching position, 3.37 per cent; to enter practice, 4.46 per cent; to enter business, 1.09 per cent; to enter other activities, 1.13 per cent, a total of 10.1 per cent, as above mentioned. The total loss of teachers above the rank of instructor, expressed in per cent per year, is about three and one-third per cent of the total number of teachers of those ranks. These figures indicate that the teaching staffs of the engineering colleges, particularly in the higher ranks, have reached a reasonably stable condition. The total turnover per year, 10 per cent, includes promotions within institutions and interchange between institutions. This figure is certainly not unduly large. The losses to practice, industry and business are small, particularly in the higher ranks. The figures do not bear out the commonly expressed belief that the industries are depriving the colleges of experienced and valuable teachers in considerable numbers—though it is no doubt true that some of our best men have been lost in this manner, particularly in some institutions.

TABLE 4 LOSS OF TEACHERS OVER A FIVE-YEAR PERIOD, 1920 TO 1924, INCLUSIVE

Rank	Left to take another teaching position	Left to enter field of engineering practice	Left to enter business	Left to enter other fields	Total losses for 5-year period cols. 3, 4 and 5	Present total numbers in institutions represented	Percentage loss of each rank per year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dean	6	4	3	4	11	70	3.1
Professor	36	36	7	15	58	487	2.4
Associate professor	21	25	5	2	32	207	3.1
Assistant professor	67	57	22	11	90	376	4.8
Instructor	171	274	65	70	409	630	13.0
Assistant	19	23	1	8	32	94	6.8
Unclassified	8	16	3	5	24	84	5.7
Totals	328	435	106	115	656	1,948	6.7
Percentage per year of present total number of teachers	3.37	4.46	1.09	1.18	6.73		

REMARKS—Teachers deceased or retired are not included in the tables. Average percentage yearly loss, professional grades, 3.35 per cent. Average percentage yearly loss, lower grades, 11.5 per cent. Total percentage turnover per year, 10.1 per cent.

TABLE 5 SUMMARY OF DEGREES HELD BY TEACHERS OF ENGINEERING STUDENTS

(143 institutions included)

Degrees	Teachers of engineering subjects including mechanics		Teachers of chemistry and chemical engineering		Teachers of sciences, including mathematics		Teachers of English and modern languages		Teachers of economics and business	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
Dr. Eng.	15	0.40	1	0.01	0	0.00	0	0.00	0	0.00
D.Sc.	66	1.79	43	2.83	66	2.65	3	0.12	3	0.29
Ph.D.	95	2.57	484	31.76	601	24.56	502	20.37	197	19.74
Professional Degrees, C.E., E.E., M.E., etc.	1,086	29.40	41	2.68	131	5.24	5	0.21	22	2.20
M.S. with specification as M.S. in C.E.	109	2.95	12	0.78	11	0.35	1	0.05	1	0.10
M.S. without specification	245	6.64	267	17.49	254	10.12	17	0.69	23	2.30
B.S. with and without specification	1,113	30.14	199	13.09	267	10.71	70	2.85	73	7.39
A.B., Ph.B., etc.	232	6.28	186	12.18	487	19.85	791	32.09	250	25.03
M.A.	116	3.15	207	13.56	517	20.06	859	34.83	251	25.13
LL.D., Litt.D., etc.	19	0.51	14	0.91	47	1.87	53	2.15	24	2.42
Other degrees	76	2.06	48	3.14	72	2.96	121	4.90	138	13.82
No degrees	521	14.10	24	1.57	41	1.63	43	1.74	16	1.59
Total number of degrees	3,693		1,526		2,494		2,465		998	
Total number of teachers	3,159		1,086		1,852		1,835		666	

Degrees Held by Teachers of Engineering Students. Through the coöperation of the Committee of the Missouri School of Mines and Metallurgy, your committee is able to present Table 5 which gives a summary of the degrees held by teachers in the several divisions of engineering curricula. There are some interesting contrasts presented by this table.

Conclusion. We believe that there will be little disagreement with the statement that the real problem before us is that of securing the right type of teachers for our engineering faculties—that this constitutes a major problem in engineering education. On it hangs the satisfactory solution of our most serious educational problems. It has been well said that engineering education will never be better than its teachers. The data presented are, we believe, furnishing us with a reliable basis of facts which will help materially in deciding future course of action in this vital manner.

CHARLES H. WARREN, *Chairman.*

Three additional reports in the Investigation of Engineering Education were issued in June, 1925. These dealt with Cost of Engineering Education, Engineering Students at the time of Entrance to College, and a Study of Admissions and Eliminations of Engineering Students.

The report on Cost of Engineering Education was a preliminary study which, however, revealed the facts that the total cost of engineering education per year in the United States is approximately $30,000,000 and the total investment in engineering-education facilities is nearly $300,000,000. The average cost per student per year was shown as follows: Endowed Universities, $582; Endowed Polytechnic Institutes, $358; Land-Grant Colleges, $298.

The Study on Engineering Students at the Time of Entrance to College points out that if our young men are, on the whole, of sound extraction and good mentality, three chief reasons may be the cause of their elimination from engineering colleges: (1) poor preparation in the high school in those subjects which form the necessary scholastic foundation for engineering training, and lack of that definiteness and thoroughness of training needed to prepare the student to follow a rigorous college course; (2) a lack of effective and valid guidance in selection of career and college course; and (3) failure on the part of the colleges themselves properly to deal with the student after admission.

The Study of Admissions and Eliminations of Engineering Students presents a large amount of data which shows that the elimination rate is high and steadily growing higher. Graduation from engineering colleges in four years is a reality for less than thirty per cent of the students entering these colleges.

Human Relations and Engineering Curricula

SOME of us feel that it is of first importance that the subject of human relations be adequately treated in engineering schools. We feel that in view of the absorption of the students in engineering problems having to do purely with inanimate matter it is important that the subject be made a required one and an integral part of the course. It should by all means be articulated with the balance of the curriculum.

We do not suggest that these courses be designed to turn out personnel specialists but merely that a general background in social economics and the problems of human organization be given. Their interest in the subject should be sufficiently aroused so that in their future careers they should follow the literature on the subject as they would on other subjects. They will then, as a matter of course, use the most modern technic and be anxious to dig out any information that is available whether from books or from their personal contact and observation. The objective is to make an interest in this subject *professionably fashionable* among engineer managers.

Personally I am speaking from experience. I refer to an industry where I found men with every quality of personality that good leaders should possess, who did not understand this problem of human relations and consequently neglected the matter. The trouble was not with their personalities, but with their training. When it came to the problem of handling the rank and file of the workingmen they acted like schoolboys. Disaster resulted.—Sam A. Lewisohn in *The Journal of Engineering Education*, October, 1925, p. 156.

Book Reviews and Library Notes

THE Library is a coöperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E. and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Books Received in the Library

ABHANDLUNGEN AUS DEM AERODYNAMISCHEN INSTITUT AN DER TECHNISCHEN HOCHSCHULE AACHEN. No. 4. Julius Springer, Berlin, 1925. Paper, 8 × 11 in., 48 pp., diagrams, 5. 10 mk.

Contents: Strömungserscheinungen in ventilen, by Bruno Eck; Gastheoretische deutung der Reynoldsschen kennzahl, by Th. v. Karman; Uber die stabilität der laminarströmung und die theorie der turbulenz, by Th. v. Karman; Uber einige anwendungen nomographischer methoden in der thermodynamik, by Bruno Eck and Erich Kayser.

These four papers present the results of experimental and mathematical investigations at the Aerodynamic Institute of the Aachen Technical High School.

A.S.T.M. TENTATIVE STANDARDS. 1925. American Society for Testing Materials, Philadelphia, 1925. Cloth, 6 × 9 in., 876 pp., illus., diagrams, tables.

Contains 193 tentative specifications, methods of test, definitions of terms and recommended practices; "tentative" being the term used for a standard proposed to the Society, but not yet formally adopted. These tentative standards, however, represent the latest thought on their subjects and are often used for lack of others. In make-up the volume corresponds to the Book of A.S.T.M. Standards. Its contents cover a wide range of engineering materials, ferrous and non-ferrous metals, cement and clay products, oils, paints, road materials, textiles, etc.

CONCRETE, PLAIN AND REINFORCED. Vol. 1: Theory and Design. By Frederick W. Taylor, Sanford E. Thompson and Edward Smulski. Fourth edition. John Wiley & Sons, New York, 1925. Cloth, 6 × 9 in., 969 pp., illus., diagrams, tables, $8.

This edition is an entirely rewritten book, to be completed in three volumes. The first volume, which exceeds the complete third edition in size, treats of design and construction and is based, the authors say, upon long and varied experience. The work is intended as a reference book for engineers, as well as for use by students. The book opens with an exposition of the theory and methods of the main design of a structure. The supplementary features, such as column heads, wall panels, openings, and beams are fully presented. Building construction is given comprehensive study, there being chapters on wall-bearing construction, basement walls, roofs, stairways, fire exits and elevator shafts, steel window sash, structural plans, chimneys, different types of buildings, and concrete in theater and auditorium construction. Henry C. Robbins contributes a chapter on the architectural treatment of reinforced-concrete structures.

CONDENSED CATALOGUES OF MECHANICAL EQUIPMENT. Fifteenth Annual Edition, 1925–26. The American Society of Mechanical Engineers, New York, N. Y., 1925. Fabrikoid, 9 × 12 in., 826 pp., illus., $5.

This publication is divided into three sections. The first contains 585 pages of condensed catalogs, in which 479 firms briefly describe their products. The second section attempts to list all first-hand manufacturers of mechanical equipment under appropriate subject headings; 4400 firms are so listed under 5000 subjects, there being 39,000 separate listings. The final section is a classified list of the specialties practiced by various members of The American Society of Mechanical Engineers.

CRAIN'S MARKET DATA BOOK AND DIRECTORY, 1925–1926. G. D. Crain, Jr., Chicago, 1925. Cloth, 6 × 9 in., 500 pp., $5 or $3 a year for continuation subscription.

A guide to trade and technical periodicals, for the use of manufacturers and advertisers. The periodicals of the country are grouped in eighty-seven classes, corresponding to the fields they cover. Information concerning the publisher, circulation, price, advertising rates, etc., is given for each periodical. Accompanying each list is a brief review of that industry, giving data on marketing conditions and possibilities. A list of foreign class journals is also given.

DYKE'S AUTOMOBILE AND GASOLINE ENGINE ENCYCLOPEDIA. By A. L. Dyke. Fourteenth edition. Goodheart-Willcox Co., Inc., Chicago, 1925. Fabrikoid, 7 × 10 in., 1233 pp., illus., $6.

The new edition of this work is as remarkable for inclusiveness and for details as its predecessors. It attempts to cover, in one volume, all the matters that may interest the student, repair man or owner, and succeeds in being unusually comprehensive and practical. Various additions have been made to the text and the illustrations, and the data retained from earlier editions have been revised.

ECONOMIC CONTROL OF INVENTORY. By Joseph H. Barber. Codex Book Co., New York, 1925. Cloth, 5 × 8 in., 114 pp., charts, tables, $2.

Modern retailers and jobbers, by frequent purchases of small stocks, are shifting the burden of carrying the reserves of finished merchandise to the manufacturer. As economical production depends upon steady, continuous operation, this irregular buying necessitates more careful study of economic conditions and better analysis of markets by the producer. This book describes in detail the method devised by the Walworth Manufacturing Co. to stabilize employment and regulate production. The plan involves a control of the stock in the business cycle by master charts which forecast orders and compare inventories with standards and estimates. The principle is applicable to other factories and other lines, according to the author.

ELEMENTARY STATISTICAL METHODS. By William G. Sutcliffe. McGraw-Hill Book Co., New York, 1925. Cloth, 6 × 9 in., 338 pp., diagrams, maps, tables, $3.

A book for college students and others interested in the collection, analysis, and presentation of economic statistical data. The treatment is an elementary one, without resort to the use of higher mathematics, and is confined principally to the exposition of standard practices in the field.

ETUDE SUR L'ECOULEMENT DES FLUIDES EN GENERAL. By A. Lebrasseur and F. D'Espine. *Chaleur et Industrie*, Paris, 1925. Paper, 9 × 11 in., 75 pp., diagrams, 14 fr.

The authors of this volume have collected and classified all the known theoretical and empirical results of researches and tests, have examined them critically and have found a basis for the elimination or revision of all doubtful data. In this way they have been able to evolve the laws and to establish formulas adapted to the different cases that occur in practice. The various circumstances that influence the flow of fluids: roughness, viscosity, friction, expansion, loss of pressure, intervention of orifices and outlets, changes in section and direction, and all the incidents that are of interest

in the design of pipe lines, are considered. The work has been published in part during the past three years in *Chaleur et Industrie*.

GASOLINE AUTOMOBILE. Vol. 4: Fuels and Carburetors. By P. M. Heldt. Published by the author, Nyack, N. Y., 1925. Cloth, 6 × 9 in., 378 pp., illus., diagrams, tables, $5.

This book covers the fuel system of the automobile; that is, the fuel tank and its appurtenances, the strainer, the piping, the feed system, the carburetor, the air cleaner, and the fuel itself. These subjects are discussed more fully than is usually done in books on car design.

In the chapters devoted to carburetors, their historical development is sketched and examples of the early types are shown. The theory of the most favored type is outlined and the principles of regulation are explained. The design of carburetor details is discussed and there is a chapter on adjusting. Descriptions of most modern types are given.

Under fuels, the author discusses the different motor fuels available, describing their sources, production, properties, the kinds of carburetors required, and the results that the fuels give.

HARVARD BUSINESS REPORTS. Vol. 1. Compiled by the Graduate School of Business Administration. A. W. Shaw Co., Chicago and New York, 1925. Cloth, 6 × 9 in., 561 pp., $7.50.

This is the first volume of a proposed series that will provide a record of business experience which will do for the executive what the law reports do for the lawyer: give him a volume of business precedents which may guide him in executive decisions. The present volume contains 149 cases selected from over 3500 cases collected by the Harvard Graduate School of Business Administration. Each case presents an actual situation which arose in actual business, describes the method adopted by the company to meet the situation and gives the reasons that inspired its selection.

INTERFEROMETER EXPERIMENTS IN ACOUSTICS AND GRAVITATION. By Carl Barus. Carnegie Institution of Washington, Washington, D. C., 1921–1925. (Publication No. 310), 3 vols. Paper, 7 × 10 in., diagrams, vols. 1 and 3, $2.50 each; vol. 2, $1.75.

The investigations carried on by Dr. Barus at Brown University during several years have given many results of interest to physicists, especially to those interested in acoustics and in the constant of gravitation. These three volumes describe in detail the work to date along these lines, as well as the results of many incidental investigations that grew out of the main experiments.

INTRODUCTION TO STATISTICAL METHODS. By Horace Secrist. Macmillan Co., New York, 1925. Cloth, 5 × 8 in., 584 pp., diagrams, maps, tables, $2.50.

Intended to provide an introductory textbook which will also be comprehensive and will give a fundamental treatment of the methods of statistical investigation and interpretation. The revised edition has been entirely rewritten, enlarged, and rearranged, so that while it retains the distinctive features of its predecessor, it is practically a new book.

DAS KRAFTWERK FORTUNA II. By Albert Schreiber. Walter de Gruyter and Co., Berlin and Leipzig, 1925. (Siemens-Handbücher, vol. 5). Cloth, 6 × 8 in., 175 pp., illus., plates, diagrams, 6.50 mk.

This book is one of a series of works issued by Siemens & Halske and the Siemens-Schuckert Works which deal with various important applications of electricity. The present volume is a description of the new Fortuna power plant near Cologne, one of the newest large plants in Europe. To describe this plant, the author adopts a form intermediate between a monograph and a textbook. The work of construction is traced step by step from the inception of the project, and a complete account of the choice and arrangement of the equipment is given, admirably illustrated by photographs, plans, and diagrams. The result is a description of a modern German electric plant which will interest engineers, students, and others.

MATERIALS TESTING, THEORY AND PRACTICE. By Irving H. Cowdrey and Ralph G. Adams. John Wiley & Sons, New York, 1925. Cloth, 6 × 9 in., 129 pp., illus., diagrams, tables, $1.50.

A small book giving a general survey of its subject and indicating basic methods of attack and interpretation, but not attempting to outline in detail any particular set of tests. It is intended as a text to accompany a laboratory course in the study of materials under stress, rather than as a laboratory manual, and represents the course given by the authors at the Massachusetts Institute of Technology.

MOTORSHIPS. By A. C. Hardy. Chapman & Hall, London, 1925. Cloth, 6 × 9 in., 292 pp., illus., diagrams, 15s.

The interest of the author is in the revolution in marine propulsion which is being brought about by the internal-combustion engine, and his book is an attempt to bring together the various aspects and points of view connected with the fitting of these engines to ships, to comment thereon, and to present the various sides of the whole question. Under four headings—construction, arrangement, evolution, and operation—the book considers the essentials of the power plant, its arrangement in the ship, the various developments of the main theme, and the effects of the internal-combustion engine upon ship construction, etc.

"NATIONAL" PIPE STANDARDS. 1924. Pittsburgh, National Tube Co., 1924. Fabrikoid, 4 × 7 in., 656 pp., diagrams, tables, $3.

A compilation of the information on tubular material which is likely to be needed by engineers and architects called upon to specify, buy, and use pipe and tubes. The new edition has been brought up to date.

SUPERHEAT ENGINEERING DATA. Sixth edition, revised. Superheater Co., New York and Chicago, 1925. Fabrikoid, 5 × 7 in., 208 pp., illus., diagrams, tables, $1.

This small book, of convenient size for the coat pocket, will be useful to operators of steam power plants. It contains information on the advantages of superheated steam and on the design and performance of superheaters, as well as much frequently needed information on coal and oil-fired boilers and on piping. A set of steam tables and a collection of miscellaneous tables are included.

WIRE-DRAWING AND THE COLD WORKING OF STEEL. By Alastair Thomas Adam. H. F. & G. Witherby, London, 1925. Cloth, 8 × 10 in., 212 pp., illus., diagrams, tables, 40s.

BRITISH WIRE-DRAWING AND WIRE-WORKING MACHINERY. By H. Dunell. Constable & Co., London, 1925. (Engineer series.) Cloth, 8 × 11 in., 188 pp., illus., 21s.

Since the last previous book on wire appeared, an interval of thirty years has elapsed, during which the investigator has been obliged to turn to the scattered information in periodicals. The lack of a modern treatise is now removed by the appearance of two works, which fortunately supplement one another to a certain extent.

Mr. Adam has not attempted an exhaustive treatment of the subject. He is interested in explaining the scientific aspects of wire drawing and cold rolling and the effects of cold working of iron and steel. He explains the real nature of wire and cold-rolled products, describes their physical properties and shows how these depend on the treatment the material has received. Such questions as the quality and preliminary treatment of the material, the extent of reduction by cold work and the relation of these matters to the properties of the product are discussed at length, while but little space is given to machinery and plant.

Mr. Dunell's book, on the other hand, is concerned especially with practical, commercial questions. Originally published as a series of articles in *The Engineer*, it describes the wire industry of Great Britain, on the basis of visits to factories. In addition to an account of general methods of wire making, it gives descriptions of the manufacture of various important products, such as woven wire, electric cable, barbed wire, wire nails, rivets, pins, needles, safety pins, wire chains, and flattened wire.

The Engineering Societies Library has prepared a bibliography of books and articles on earth and gravel roads published between January, 1920, and June, 1925. It contains 140 references with brief annotations. Copies of this bibliography, which is known as No. S-4085, may be obtained for $1.50 each from the Engineering Societies Library, 29 West 39th Street, New York.

THE ENGINEERING INDEX

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LAST-MINUTE ADDITIONS; MAIN BODY ON PAGE 103-EI, ADVERTISING SECTION

Exigencies of publication make it necessary to put the main body of The Engineering Index into type considerably in advance of the date of issue of "Mechanical Engineering." To bring this service more nearly up to date is the purpose of this supplementary page of items covering the more important articles appearing in journals received up to the third day prior to going to press.

AIRPLANE ENGINES

Paris Show. Aircraft Engines at the Ninth Paris Aeronautical Show (Flugmotoren auf der neunten Pariser Luftfahrtausstellung), F. Gosslau. Zeit. des Vereines deutscher Ingenieure, vol. 69, no. 42, Oct. 17, 1925, pp. 1325–1329, 13 figs. With exception of a 1000-hp. 4-engine group of Bréguet and 450-hp. Panhard engine, development continues along well-known lines; further development of 4-cycle valve engine with aim in view of achieving maximum operating safety with light weight and durability; Rateau blower is attached to 300-hp. Renault engine.

AIRPLANES

Autogiro Flying Machines. The Autogiro Flying Machine. Engineer, vol. 140, no. 3643, Oct. 23, 1925, p. 430, 2 figs. Results of tests conducted at Royal Aircraft Establishment, Farnborough, to demonstrate capabilities of system invented by Spanish engineer, J. de la Cierva. See also Engineering, vol. 120, no. 3121, Oct. 23, 1925, p. 521, 2 figs.; and Flight, vol. 17, no. 43, Oct. 22, 1925, pp. 683–687, 8 figs.

AUTOMOBILES

Brakes, Four-Wheel. Four-Wheel Brakes for Automobiles (Vierradbremsen für Kraftwagen), A. Heller. Zeit. des Vereines deutscher Ingenieure, vol. 69, no. 41, Oct. 10, 1925, pp. 1297–1300, 10 figs. Front-wheel brakes with flexible or rigid brake-cam drive; equalization of braking effects; standardization of front axles.

BEARINGS, ROLLER

Anti-Friction, Operation on Crankpin. Operation of Anti-Friction Bearings on Crankpin Analyzed, J. Kirner. Automotive Industries, vol. 53, no. 18, Oct. 29, 1925, pp. 738–744, 24 figs. Rollers inserted between crankpin and lower connecting-rod bearing have triple, and cages dual, motion; these motions and resulting inertia forces are determined, partly by graphical means. Mathematical research undertaken in connection with development of roller bearings for engines of airship Los Angeles, when under construction in Germany.

BELTING

Performance Data. Performance Data on Belting, W. W. Nichols. Mgmt. & Admin., vol. 10, no. 5, Nov. 1925, pp. 259–260, 4 figs. Its purchase and installation, and methods of obtaining power consumption of machinery.

BOXES

Shipping Containers. Selecting the Proper Container. Mgmt. & Admin., vol. 10, nos. 4 and 5, Oct. and Nov. 1925, pp. 199–200 and 271–272. Factors that manufacturer must weigh to bring about economy in shipping costs; points out that few plants can profitably make their own containers.

CENTRAL STATIONS

Design, Factors of. The Modern Central Station (Das neuzeitliche Elektrizitätswerk), G. Klingenberg. Zeit. des Vereines deutscher Ingenieure, vol. 69, no. 41, Oct. 10, 1925, pp. 1285–1288, 2 figs. Based on design of Rummelsburg-Berlin station according to plans developed by author, leading factors in planning of such designs, such as choice of steam pressure, application of intermediate superheating, pulverized-coal firing, etc., are considered.

Fulham, England. Extensions to Fulham Electric Power Station. Engineering, vol. 120, no. 3120, Oct. 16, 1925, pp. 488–490, 1 fig. New boiler plant consists of 3 Vickers 5-drum, bent-tube-type boilers, each having 10,000 sq. ft. of heating surface, and giving normal evaporation of 40,000 lb. per hr. at pressure of 275 lb. per sq. in., feed being supplied at temperature of 200 deg. fahr.; two new turbo-generators were constructed by Metropolitan-Vickers Elec. Co., each rated to develop 6000 kw. continuously.

COAL

Carbonization. The Case for Low-Temperature Carbonization in America Today, H. W. Brooks. Power, vol. 62, nos. 17 and 18, Oct. 27 and Nov. 3, 1925, pp. 634–638 and 680–684, 7 figs. American and European conditions compared; it is concluded that economic and technical conditions in Europe being quite different, different solution of carbonization must be worked out in America to earn dividends at present time; low-temperature carbonization is adapted more adequately to dividend-paying possibilities in America than by-product coke-oven methods; preferred process of low-temperature carbonization should either carbonize raw coal in pulverized form or pulverize and carbonize simultaneously; processes recommended are not only technically but financially feasible and apparently offer to American power-plant operators only probability of further large reductions of fuel costs.

COMBUSTION

Calculation. Combustion Analysis (Die Verbrennungsrechnung), A. B. Helbig. Zeit. des Vereines deutscher Ingenieure, vol. 69, no. 42, Oct. 17, 1925, pp. 1323–1324. New system of calculating atom-filled space makes it possible to evolve a unit form of analyses for all fuels, gases and exhaust gases, as well as equations for the four effective elements in generation of heat, from which formulas for volume of exhaust gas, volume of air, and carbon loss can be derived; development of analysis of combustible constituents of fuel simplifies chemical preliminary work of combustion calculation.

COST ACCOUNTING

Labor Costs. A Practical Accounting System for Labor Costs, H. M. Grasselt. Indus. Mgmt. (N. Y.), vol. 70, no. 5, Nov. 1925, pp. 284–286, 4 figs. How paper mill controls its labor budget.

CRANES

Electric. The Design and Construction of Electric Cranes, D. Adamson. Engineer, vol. 140, no. 3644, Oct. 30, 1925, pp. 460–461, 3 figs. Construction and maintenance of electric overhead traveling cranes.

DIESEL ENGINES

Compressorless. The Compressorless Operation of Diesel Engines (Der kompressorlose Betrieb von Dieselmotoren), F. Schultz. Zeit. des Vereines deutscher Ingenieure, vol. 69, no. 41, Oct. 10, 1925, pp. 1289–1296, 4 figs. Development of working process; basic design and designs developed by different firms; fuel nozzles and pumps; degree of condensation and ignition pressure, shape of combustion chamber; thermotechnical factors. See also article entitled, Compressorless Oil Engines (Kompressorlose Oelmaschinen), by E. Kux, pp. 1294–1296, 4 figs., based on author's contribution to discussion of above paper by F. Schultz.

ELECTRIC LOCOMOTIVES

Diesel-Electric. Practical and Experimental Results of the Russian Diesel-Electric Locomotive (Betriebs- und Versuchsergebnisse der russischen dieselelektrischen Lokomotive), F. Meineke. Zeit. des Vereines deutscher Ingenieure, vol. 69, no. 42, Oct. 17, 1925, pp. 1321–1323, 4 figs. Investigations of Lomonossoff locomotive in Germany.

ELECTRIC WELDING, ARC

Steel-Mill Repair Work. Economical Repairs by Welding, A. M. Candy. Iron Age, vol. 116, no. 20, Nov. 12, 1925, pp. 1307–1309, 9 figs. Steel-mill maintenance work expedited by use of arc process; applications include repairing of cars and locomotives.

FACTORIES

Location. Analyzing the Problem of Plant Location, H. R. Parker and R. L. Kraft. Indus. Mgmt. (N. Y.), vol. 70, no. 5, Nov. 1925, pp. 301–304, 1 fig. Study of factors influencing selection of factory location, and their effect on some of larger industries.

Modern Design. The Modern Manufacturing Plant, J. R. Thomas. Mgmt. & Admin., vol. 10, no. 5, Nov. 1925, pp. 261–264, 4 figs. New plant of Hall Planetary Co. represents marked advance in lighting, heating and power transmission.

FOUNDRY EQUIPMENT

Scraper Bucket. Electric Scraper Bucket for Foundry Use. Iron Age, vol. 116, no. 20, Nov. 12, 1925, p. 1318, 1 fig. Appliance intended for use in foundries which employ sand cutters for preparing molding sand; foundry floor area of 5 ft. by 16 ft. is cleaned up by bucket in approximately 20 sec., leaving foundry sand in 4-ft. piles.

GEARS

Non-Metallic. Making and Testing for Non-Metallic Gears, F. H. Colvin. Am. Mach., vol. 63, no. 19, Nov. 5, 1925, pp. 725–728, 14 figs. Steps by which fabric is impregnated with suitable compound and made into material for gears adapted to many uses.

Variable-Transmission. The Hele-Shaw Beacham Variable Transmission Gear. Engineering, vol. 120, no. 3120, Oct. 16, 1925, pp. 477–480, 19 figs. Gear consists of two main components, viz., pump with variable stroke and constant-stroke hydraulic motor; variable-throw pump is coupled to some prime mover and supplies oil by which motor is driven.

INDUSTRIAL MANAGEMENT

Mechanisms of Management. Skillful Use of Management Tools. Mgmt. & Admin., vol. 10, no. 5, Nov. 1925, pp. 249–250. Results of budgeting, employee suggestions, payroll procedure, tool control, and production control.

Tool Systems. Worthington Methods for Tool Storage, Use and Repair, A. L. Christiansen. Mgmt. & Admin., vol. 9, nos. 5 and 6, and vol. 10, nos. 1, 2, 3 and 4, July, Aug., Sept. and Oct. 1925, pp. 467–470, 537–540, 15–18, 95–97, 141–144 and 201–204, 15 figs. May: Methods of distributing tools; tool classification; classified numbering (Dewey decimal system); mnemonic lettering system; tool crib. June: Building and starting tool crib. July: Tool issuing; standard tool lists; tool kits for specific jobs; classes of tools for erection jobs. Aug.: Regulation of inspection, accounting and executive supervision. Sept.: Organizing tool-crib personnel. Oct.: Development and maintenance control.

IRON AND STEEL

Standardization. German Standards for Iron and Steel (Die deutschen Werkstoffnormen für Stahl und Eisen), E. H. Schulz. Zeit. des Vereines deutscher Ingenieure, vol. 69, no. 43, Oct. 24, 1925, pp. 1341–1346. Aim and expediency of standardization of steel and iron as work material; peculiarities and difficulties of materials standardization; critical discussion of standards already developed and future prospects.

IRON CASTINGS

Furnace Scrap. Bad Castings and Furnace Scrap, H. H. Hopkins. Iron Age, vol. 116, no. 19, Nov. 5, 1925, pp. 1252–1253. Discusses question as to whether use of pig iron, made partly with scrap, results in defective castings; concludes that evils attributed to use of scrap are probably overrated.

LIGHTING

Factories. How Good Lighting Benefits the Shop, A. G. Anderson. Mgmt. & Admin., vol. 10, no. 5, Nov. 1925, pp. 277–280, 6 figs. Data by which plant manager can measure relative effectiveness of his factory illumination.

MOLDS

Plastic Process. Metal Molds by a New Process, M. S. Clawson. Iron Age, vol. 116, no. 20, Nov. 12, 1925, pp. 1310–1313, 7 figs. Accurate castings claimed possible by "plastic process"; new electric resistance furnace used; process relates to casting of steel and nickel alloys to sufficiently close dimensions so that only grinding and finishing are required to produce complete die for stamping or mold for forming materials now being used for different purposes; such as sheet metal, bakelite, asbestos, compositions, etc.; permanent molds.

OIL

Production from Coal. The Liquefaction of Coal (Die Verflüssigung der Kohle), F. Bergius. Zeit. des Vereines deutscher Ingenieure, vol. 69, nos. 42 and 43, Oct. 17 and 24, 1925, pp. 1321–1323 and 1359–1362, 15 figs. Author maintains that world production of petroleum will in future not be sufficient to supply demand, and Europe, particularly, will be forced to produce oil synthetically; coal distillation; physical and chemical processes; the Bergius process; experimental results and practical experiences extending over number of years in Rheinauer plants led to erection of industrial coal-liquefaction plant.

OIL ENGINES

High-Speed. Langley Field Research on High-Speed Oil Engines, R. Matthews. Power, vol. 62, nos. 18 and 19, Nov. 3 and 10, 1925, pp. 685–688, 4 figs.; and 714–715, 3 figs. Nov. 3: Experiments prove that high-speed engine cannot be made of converted gasoline engine, but point way to ultimate success. Nov. 10: Air-steam ignition for oil engines; possibilities of 2-stroke-cycle operation with injection and electric ignition.

PRESSWORK

Automobile-Parts Manufacture. Press Work and Welding Combined in Parts Manufacture, L. S. Love. Automotive Industries, vol. 53, no. 17, Oct. 22, 1925, pp. 704–706, 15 figs. All-steel tops, doors, windshield bases, stanchions, axle housing and other units are made at plant of Heintz Mfg. Co. from sheet-steel stampings, which are welded together in fixtures; close limits maintained.

PULVERIZED COAL

Thermodynamic and Practical Features. Thermodynamic and Practical Features of Pulverized-Coal Firing, Dr. Rosin. Power, vol. 62, no. 19, Nov. 10, 1925, pp. 739–740. Author shows impossibility of spontaneous explosion of gas-freed coal dust, discusses effect of fine milling with high-ash coals and explains importance of correct flame length in relation to furnace deterioration. Abstracted translation from Braunkohle, June 13, 1925.

PUMPS

Vacuum. A Gas-operated Vacuum Pump. Engineer, vol. 140, no. 3644, Oct. 30, 1925, p. 462, 1 fig. Describes method and apparatus for employing combustion of gas for direct production of partial vacuum, invented by B. Joy; primarily intended for suction cleaning in domestic service, but could be used for variety of other purposes.

RAILWAY MOTOR CARS

Diesel-Electric. Diesel-Electric Rail Cars in Canada. Engineer, vol. 140, no. 3643, Oct. 23, 1925, pp. 430–431, 10 figs. partly on p. 434. Particulars of two types of passenger rail cars fitted with new design of all-steel quick-running oil engines built by Wm. Beardmore, Glasgow; dimensions of cars.

VISCOSIMETERS

Electrically Controlled. Tagliabue Electrically Controlled Viscosimeter. Power, vol. 62, no. 19, Nov. 10, 1925, p. 738, 1 fig. Electrically heated, stirred and controlled Saybolt viscosimeter, developed by C. J. Tagliabue Mfg. Co., Brooklyn, N. Y.

WAGES

Group Premium. Group Premium for an Automatic Screw Machine Department, L. H. Houlihan. Mgmt. & Admin., vol. 10, no. 5, Nov. 1925, pp. 281–284, 1 fig. Disadvantages of individual premium; allowance for premium; standard times; premium formula; advantages of group premium; results.